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Theodore Roosevelt Jun.
With the Author's
kind regards.

JOHNSTONE, J.
C

A

DISCOURSE

ON THE

PHENOMENA OF SENSATION

AS CONNECTED WITH THE

MENTAL, PHYSICAL, AND INSTINCTIVE FACULTIES OF MAN.

BY

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THE following pages contain the substance of a Course of Lectures delivered by the author in the spring of 1838; but a considerable part was written some years ago, and a few additions have been subsequently made.

The work being in its present state much longer than was originally intended, the author has refrained from illustrating some portions of it so fully as he might have done; and he begs especially to refer those who may wish to make further investigations, to the excellent writings of Abercrombie, Adelon, Bell, Bichat, Bostock, Thomas Brown, Cuvier, Cabanis, Cullen, Elliotson, Fletcher,

Grainger, Hall, Hartley, Locke, Magendie, Mayo, Müller, Reid, Richerand, Roget, Solly, Dugald Stewart, Tracy, Tiedemann, and Gmelin, to all of which he acknowledges his obligations.

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	19		10	former	latter.
	22		27	ninth	eleventh.
	23		7	ganglion . . . forms	ganglia . . . form.
	26		30	is . . . consists	are . . . consist.
	73		9	talicotian	Taliacotian.
	104		16	lowest	lower.
	108		24	liable	liable to.
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	147		12	dgree	degree.
	188		29	not so easy	not easy.
	199		5	are	is.

THE

PHENOMENA OF SENSATION,

&c. &c.

INTRODUCTION.

NOTWITHSTANDING the numerous varieties of external shape and internal structure which distinguish the fish from the reptile, the bird from the quadruped, and all from man, yet is the organization of every animal adapted to perform a certain set of functions, which are essential to the existence of the individual and to the propagation of the species. The attributes which are thus common to all animated beings may be divided into three classes: 1st, animation; 2d, nutrition; 3d, generation.

The processes whereby these phenomena are produced are most simple in the lowest, and most complicated in the highest tribes. In man, the

animative function comprises sensation, the cerebral or mental faculties, the voluntary, semivoluntary, and involuntary motions, sympathy, instinct, and sleep; the nutritive function consists of digestion, absorption, respiration, circulation, secretion, and excretion; while the generative function includes impregnation and the formation of the fœtus. It is of the first of these classes that I am about more especially to speak in the following discourse, wherein I shall endeavour to show how far the vital operations are dependent upon the influence of sensation.

CHAPTER I.

OF THE OPINIONS OF THE OLDER PHILOSOPHERS AND PHYSIOLOGISTS RESPECTING THE ORGANS OF SENSATION.

The earliest remarks on the Physiology of Sensation are found in the works attributed to Hippocrates, wherein the brain is regarded as a glandular body, because, like the glands, it is white, brittle, and spongy.

He thought that, in common with the glands, its spongy texture imbibed the superfluous fluids of the body; and that, being round and hollow, it attracted humidity in the form of vapour from every part of the body. When the head was filled with this humidity, he conceived that the fluid was sent back to the trunk, and especially to the glands, whence the superfluous matter passed off in fluxes and catarrhs. He, however, justly says, in the treatise on Epilepsy, that the brain is the seat of the understanding and of wisdom; but in the book on the Heart, he tells us that the reasoning faculty resides in the left ventricle of that organ. This inconsistency can only be explained by the supposition that one of these works was written by another author. Hippocrates was acquainted with two of the three membranes where-

with the brain is invested, one of which he describes as thick, the other as having a thin texture. He was also aware that the nerves are organs of sensation as well as of motion, and he distinctly mentions both the spinal cord and sympathetic nerve.*

Plato† imagined that the spinal marrow was the seat of life, or the organ by which the soul is connected with the body; but that the brain, which he says is a continuation of the spinal cord, was the receptacle of the soul or divine spirit itself!

Aristotle‡ speaks of the five senses of feeling, tasting, smelling, hearing, and seeing; of which, he says, the sense of feeling is alone common to all animals, the others being peculiar to certain tribes.

He states that the sense of feeling is diffused throughout the body, and does not reside in any particular part, but that the heart is the great focus or centre of the sensations, of mobility, of reason, of the passions, of the vital spirit, and of nourishment. He also asserts that the nerves arise from the heart, and that the brain is a mass of water and earth devoid of blood, and perfectly insensible; that it is a cold body, whose office it is to temper the heat of the heart; and that though situated above the spinal cord, it is totally different in its nature, the spinal marrow being a kind of

* See Hippocrates, Περὶ Ἀδένων, Περὶ Καρδίης, and Περὶ Ἱερῆς νόσου.

† See the Timœus. ‡ Περὶ Ζωων Ιστοριας.

blood, which is prepared for the purpose of nourishing the bones.

Praxagoras agreed with Aristotle that the nerves arise from the heart, and he also believed that the arteries terminate in nerves, the cavity being obliterated towards their extremities. He moreover maintained that the brain was of scarcely any use, and was merely an appendage to the spinal cord.

Such were the opinions of the ancient Greek philosophers with regard to sensation, until Erasistratus and Herophilus ascertained the principal functions of the nerves by dissection of the human body. Before their time, brutes alone had been subjected to inspection after death; but these anatomists, unsatisfied even by examining the dead body of man, gratified their curiosity by the inexcusable and useless barbarity of dissecting living criminals, who were dragged from the prisons.

Erasistratus, it is supposed, knew that there were two kinds of nerves, the one motory, the other sensitive. He describes the human brain as being like that of other animals, divided into two parts. He observes that the brain of man has more convolutions than those of animals, and that to this more complicated structure his superior intelligence is attributable. He also speaks of the cerebellum, of the ventricles, of the membranes, and of the connexion of the organs of hearing and seeing with the brain, by means of the nerves.

Herophilus held the same doctrines as Erasistratus, and moreover believed that the soul is situated in the ventricles of the brain.

Aretæus tells us that the brain is the cause both of the animal motions and of sensation, and that the nerves are dependent on it. He conceived that the soul was lodged in the heart, but that the liver was the seat of the animal appetites. He was acquainted with the influence which affections of the stomach exercise over the mind, and therefore thought that it was the source both of pleasure and of sadness.

The next great step in the progress of physiological science was made by Galen; of whose opinions with regard to the nervous system, I shall quote the account given by Dr. Kidd in his excellent analysis of the works of Galen.

"Galen remarks that sensation and voluntary motion essentially distinguish animals from plants; and that, on this principle, nerves constitute a muscle an animal organ, which, with reference solely to its arteries, veins, &c., is a merely physical organ. He supposes, however, that nerves do not possess an inherent and independent power, but whatever power they have is derived from the brain, from which, though they have no perceptible cavity within them, they are capable of conveying sensation and power of motion to the most distant parts of the body. He conjectures that there are nerves for three distinct purposes; namely, for sensation, for motion, and for the discrimination of what may be salutary, and what injurious to the system, the last mentioned belonging particularly to the stomach and intestines, and to the urinary bladder; and that, in consequence of this 'organic sensibility,'—for to Galen's doctrine that term may be justly applied,—

these parts are capable of attracting or repelling whatever may be respectively useful or the contrary. He makes a distinction between the powers of voluntary and involuntary motion; and observes, that those organs of sense which are obedient to voluntary motion, as the eyes and the tongue, require consequently two sets of nerves; and with respect to the tongue, he points out particularly those nerves which belong to it as an organ of taste, and those which render it capable of voluntary motion." He also describes the spinal cord; and "in stating the fact that all the nerves which arise from the brain and spinal cord arise in pairs," he adds his opinion, "that sensation and voluntary motion are dependent on the brain through the medium of these nerves." He asserts, "that the use of the pia mater is to hold together the arteries and veins of the brain, and also to give support to the substance of the brain, and prevent it from collapsing;" while, in other respects, his description of the brain is very similar to that which is given at the present day. Galen thought it probable that sensation and the power of motion were not derived from the *same* kind of nerves. After the time of Galen, physiology seems to have somewhat retrograded, for we find that instead of seeking for the springs of the vital properties in the functions of the body, which are their natural and obvious source, Stahl attributed the phenomena of life to what he calls *anima*, the soul, which he conceived to be independent of the body, and nowise influ-

enced by its physical condition. He seems to make use of the word anima to signify the *vital principle*, and not as the word soul is commonly employed. According to Stahl, the anima directs the motion of our organs, and excites or stops them at pleasure; but Hoffman justly referred this power to the nervous system, and this opinion has ever since almost universally prevailed.

To the physiological writers who have been mentioned, I might add the names of Haller, whose "Elementa Physiologiæ" is an imperishable monument of his genius, and who so strenuously defended the doctrine that muscles contract without the agency of nerves, of his opponent Whytt, and of Cullen, who, although he held the erroneous opinion that "muscular fibres are a continuation of the medullary substance," must ever rank among the first physiologists and physicians of his own or of any age: but these distinguished persons belong to modern times; and as I shall have occasion very frequently to refer to their writings, we shall pass them by for the present, and proceed to speak of the composition and texture of nervous matter.

CHAPTER II.

OF THE COMPOSITION AND TEXTURE OF NERVOUS MATTER.

VARIOUS facts and experiments have clearly demonstrated that sensation is a function of the nervous system.

It must however be admitted that in some of the inferior orders of animated beings which certainly appear to be sensible of external impressions, no system of nerves or vestige of nervous matter has yet been discovered; but as, in the higher classes, sensation is always manifested in proportion to the development of the ganglionic, spinal, and cerebral systems, we must conclude that neurine forms a component part of even the most simply organized animals, though in the lowest tribes it is distributed in such minute portions as to escape detection.

Neurine is soft, rather tenacious, varies in colour, and consists of two distinct substances; the one of which is gray, and the other white: the first is called the cortical or cineritious matter; the second the medullary matter, though the term *medullary* matter is very commonly used to denote the whole nervous tissue or neurine, including both the gray and the white portions.

According to the analysis of John, nervous matter consists of water, albumen, white fatty matter, red fatty matter, osmazome, and earthy phosphates; the gray substance containing more water, red fatty matter, and osmazome, but less albumen, white fatty matter, and earthy phosphates than the white.

Vauquelin, by analyzing the brain, obtained from it water, white fatty matter, reddish fatty matter, albumen, osmazome, phosphorus, acids, salts, and sulphur. To the white fatty matter Couerbe has given the name *cerebrote*. Frémy regards the cerebral substance as a kind of soap, formed by the union of soda with two new fatty acids, but moreover containing cholesterine.

Gaul advanced the idea that the white matter is secreted by the gray; but this seems to have been disproved by Tiedemann, who remarks, that the medullary matter is visible in the fœtus before the cortical substance can be detected.

Prochasca believed both the cortical and medullary substances to consist of an immense quantity of globules united together by an elastic and very transparent cellular membrane; but subsequent investigations have proved that this opinion is erroneous.

Each nerve is a fasciculus of small cylinders, which are invested by a thin membrane.* These tubes are connected at intervals with each other; but their primitive fibres, according to Müller,

* For a full account of the nervous structure, see Müller's Physiology, whence many of the following facts are taken.

never unite, though they are very frequently interchanged and pass from one fasciculus to another. The primitive fibres are minute threads, which in man vary from $\frac{1}{370}$ to $\frac{1}{184}$ of a line in diameter, and are very similar, both with respect to shape and size in all animals. Fontana * observed an external cylindrical portion with a wrinkled surface, containing an internal thread; and upon separating the sheath from its contents, he found that about half the tube was formed of an uniform transparent smooth thread, while the remainder was rough, less transparent, irregular, and much thicker. He says, "I then suspected that the primitive nervous cylinder was formed of a transparent cylinder, smaller and more uniform, and covered with another substance, the nature of which was perhaps cellular. The observations I afterwards made invariably confirmed me in this hypothesis, which became an established fact. I have very often seen these two parts that compose the primitive nervous cylinder. The exterior one is unequal and rugged; the other is a cylinder which seems to be formed of a peculiar transparent and homogeneous membrane, that appears to be filled with a gelatinous consistent humour." After detailing some experiments, he then proceeds: "On examining the external covering of the primitive nervous cylinders with attention, it seemed to be composed of winding threads, running along the nerve, and so forming a cover to the inte-

* Observations on the structure of the nerves in Fontana's work on Poisons.

rior cylinders." He concludes that "the primitive construction of the nerves is as follows: a nerve is formed by a great number of transparent, homogeneous, uniform, very simple cylinders. These cylinders seem composed of a very fine uniform tunic, filled, as far as the eye can judge, with a transparent gelatinous humour, not soluble in water. Each of these cylinders receives a cover in form of an external sheath, which is composed of an immense number of winding threads. A very great number of transparent cylinders form together an almost invisible nerve, presenting the exterior appearance of white bands, and several of these united form the larger nerves seen in animals." According to Bogros, independent of the neurilemma and pulp, a central canal is to be recognized. With the assistance of minute tubes he injected nerves with quicksilver, and, according to his statements, it not only penetrated all the filaments of the nervous cord, but the injection has been traced into the papillæ of the skin, the mucous membranes, and muscles; and lastly, when only one filament has been injected, it has extended into several others by means of *anastomosing canals.*

Remak, whose observations are alluded to by Müller, describes the contents of the nervous cylinder to be either a perfectly solid fibre of rather less diameter than the cylinder itself, or a flattened pale thread separable by pressure for a considerable extent from the investing tube, which readily becomes wrinkled. He also states that the primitive

fibres of the gray matter, such as those of which the ganglionic nerves consist, are much smaller and less distinct than those of the white substance.

It is, however, somewhat doubtful whether the minute fibres described by Fontana and Remak are really the primary fibres, since Treviranus discerned still smaller filaments in these cylinders. Ehrenberg informs us that nervous matter consists of very minute fibres, which in the cortical part are interspersed with globules and plates. Most of the fibres have a beaded appearance, and the smaller portions, which are situated at short distances from each other, are united by filaments of the same substance.

He observed, moreover, another set of fibres, which were larger and regularly cylindrical, and of which the nerves of motion and of common sensation are composed; while the brain, spinal cord, and nerves of special sense, consist of the articulated or varicose fibres, and both kinds enter into the composition of the sympathetic nerve. The regularly cylindrical fibres contain a pithy substance, whereas a transparent gelatinous fluid is found in those which are articulated.

But, notwithstanding these researches, Müller and Treviranus are of opinion that all primitive nervous fibres, in the brain as well as in the nerves, are plain straight tubes, and that the varicosity is only produced when the parts are subjected to pressure, and consequently give way. Müller nevertheless admits that the fibres of the brain and

nerves of special sense are exceedingly prone to become varicose.

Ehrenberg further asserts that the cortical differs from the medullary matter, inasmuch as the former has no straight cylindrical fibres and is supplied with a larger number of blood-vessels than the latter.

Valentin affirms that the gray substance, both of the brain and of the ganglia, is composed of globules, while, according to Rolando and Remak, the spinal cord contains two kinds of gray matter: one of which consists of globules similar to those in the other nervous centres, but mixed with fibres; and the other, of globules resembling the red particles of frog's blood.

It has also been discovered that nervous fibres may terminate either by the ends of two of them meeting so as to make a loop, in the form of network, or in a single point.

Müller enters on this subject at considerable length; but as the facts which are supposed to have been ascertained entirely rest for proof upon minute microscopic observations, we cannot implicitly rely upon them.

CHAPTER III.

OF THE DISTRIBUTION OF THE NERVOUS MATTER IN VARIOUS CLASSES OF ANIMALS.

THE minute structure and composition of nervous matter being such as I have described, we shall now proceed to review the several modes in which it is distributed, so as to suit the organization and minister to the existence of the lowest as well as of the highest classes of animals.

The nervous system may be divided into three distinct parts, namely, the sympathetic or ganglionic system; the spinal system, and the cerebral system, having for their respective centres the ganglia, the spinal cord, and the brain. Some of the lower animals, however, have apparently no vestige of a nervous system, while in many others it is very imperfect and only discernible by the aid of a microscope. In sponges and medusæ nothing like nervous matter can be detected, and in several other species of the radiated animals, a few scattered white granules are the only traces of it. Nevertheless, they contract when touched, and display other signs of sensibility, which would lead to the suspicion that nervous matter is mixed up with the granular or gelatinous parts of their bodies, though it is not cognizable by our senses.

In speaking of the polyps, Cuvier* remarks that they have very distinct sensations: their sense of touch is very delicate; they not only perceive the motions which agitate the water wherein they live, but they feel the degrees of heat and light. The expansion of the actiniæ corresponds precisely to the serenity of the atmosphere. The hydra perceives the presence of light; it prefers it, and turns towards it.

In the higher radiated animals, the nervous system consists of a ring, surrounding the orifice of the stomach, on which in many tribes several ganglia are situated, and of nerves which, arising either from the ring or from the ganglia, are distributed to the rays. On examining the hydatina senta, Ehrenberg discovered six or seven gray bodies enveloping the upper part of the œsophagus. The uppermost, which he considers as a ganglion, is larger than the others, and sends off nerves which, by their union with another ganglion at the back of the neck, form a nervous ring; whence filaments proceed both to the head and to the abdomen. The nervous system of the ascaris consists of two white cords, composed of a series of small lines united at angles, or as it were broken and slightly swollen at each angle, sending to each side numerous filaments. Of these cords one passes along the dorsal, and the other on the abdominal surface of the alimentary canal. J. Cloquet

* Cuvier's Comparative Anatomy.

regards the enlargements as ganglia; and to me this nervous system appears to present a perfect type of the sympathetic nerves; but Mr. Solly, to whose admirable book on the Brain I am indebted for the above facts, thinks that these cords do not represent a mature nervous system, which he conceives in this individual has been arrested in its development at a period corresponding to one of the regular stages, through which the nervous system passes in the higher orders, wherein the nerves are developed first, and their centres afterwards.

The nervous system of the articulated animals is composed of two long cords, together with several ganglia; the first of which is placed over the œsophagus, and, being connected with the nerves of external sensation, has by some anatomists been called a brain, though in its structure it resembles the other ganglia. In this class, Professor Grant has pointed out a distinct set of motory nerves, which pass over but do not penetrate the ganglia; whereas, the nerves of sensation arise from ganglia.

The uniform distribution of the ganglia upon the cords which extend throughout the length of the body in several of the articulated animals seems designed to furnish each division with a nervous centre, and render it in some degree independent of the adjoining parts.

In the mollusca, the nervous system consists of several medullary masses, which are scattered over

the viscera, and connected with each other by nerves. As in the articulated animals, one of these masses or ganglia, being larger than the rest, is called a brain, whence arise the nerves of external sensation. The nervous system of the lower animals of this class very closely resembles that of the articulata, but in the higher orders it is distinguished from them by the much larger size of the ganglia in proportion to the nerves. With the exception of one family, the mollusca are destitute of the senses of hearing and of smelling ; and many of them do not seem to possess any part which can be compared with the spinal cord of vertebrated animals, notwithstanding the anxiety of some physiologists to prove that something analogous to it exists in every nervous system. In the snail, for example, the brain is situated on the œsophagus, around which it sends two branches, so as to form a collar of nervous matter, and to unite in a large round ganglion of more than half the size of the brain itself. From the brain, nerves go to the horns, the eyes, the mouth, &c., while from the ganglion branches proceed to the viscera, and to the large muscles, by which it moves itself in the shell.

The larger ganglion evidently represents either the cerebrum or the whole brain, but what is the smaller? Is it the cerebellum, the medulla oblongata, or the substitute for the sympathetic nerve ; or does it perform the functions of all or any of these organs?

The vertebrated animals are distinguished from the other classes as much by the perfection of the nervous system as by the symmetry of their external form. They exercise the five senses of feeling, tasting, smelling, hearing, and seeing. They possess a definite spinal system, ganglia, and a brain. The spinal cord is by some anatomists considered as a production of the brain, while by others the brain is regarded as an appendage to the spinal cord. The former opinion was held by Gall, who says that bundles of fibres proceeding from the upper parts of the spine expand so as to form the cerebrum and cerebellum; whereas Magendie says that the brain is no more an enlargement of the spinal marrow than the spinal marrow is a prolongation of the brain. Tiedemann, however, supports Gall's views of this subject, resting his opinion upon the progressive development of these parts in the fœtus; but he does not agree with him in thinking that the spinal cord is composed of ganglia; for, as he very justly says, if this were its structure it would be apparent in the fœtal state, which is not the case. Mr. Solly conceives the brain to be no more than a series of ganglia, or collections of cineritious neurine, in which the nerves of sensation terminate, and from which the nerves of motion arise.

From a comparison of the nervous systems in all animals I should infer that either the ganglionic or the spinal system is sufficient for those animated beings whose actions are purely instinctive; but the cerebral system is necessarily superadded to it in

those which require the aid of reason and volition in providing for their subsistence.

Hence we find that in the higher quadrupeds, such as the elephant, the brain bears a far larger proportion to the other parts of the nervous system than in either birds or fishes; while in man, whose mental and mechanical powers vindicate his superiority over the other inhabitants of this world, it is in its most perfect state.

CHAPTER IV.

OF THE NERVOUS SYSTEM OF MAN.

In a physiological point of view, the nervous system of man, like that of the other vertebrata, consists of three parts: the sympathetic or ganglionic, the spinal, and the cerebral divisions; all of which, as I have already stated, exist in the higher classes of animals, but are only partially developed in the lower tribes.

I. By anatomists of this country the ganglionic system has been usually described as commencing in the carotid canal by the vidian nerve uniting with two or three branches from the sixth pair; it is, however, a system distinct and independent of the nerves proceeding from the brain and medulla spinalis. It may be divided into cranial, cervical, thoracic, abdominal, and pelvic portions, presenting a continuous trunk formed by filaments of communication with the different ganglia.

The ganglia may be divided into those of the head, neck, chest, abdomen, and pelvis.

Those of the head are the ophthalmic, the sphenopalatine, the otic, the cavernous, the naso-palatine, the submaxillary, and Ribes's ganglia. From the ophthalmic ganglia are given off the ciliary nerves

and filaments of communication with the third pair, and with the first division of the fifth nerves. From the spheno-palatine ganglia proceed the palatine, spheno-palatine, and vidian nerves, communicating with the second division of the fifth pair, with the sixth and seventh pair, with the glosso-pharyngeal plexus, and with the cavernous, naso-palatine, and superior cervical ganglia. From the otic ganglia arise twigs of union with the third division of the fifth, with the facial nerve, and with the tympanic plexus, chorda tympani, carotid plexus, and first cervical ganglion. From the cavernous ganglia, arise filaments of communication with the ophthalmic and first cervical ganglia, and with the sixth pair of nerves. From the naso-palatine ganglia arise branches of communication with the palatine nerves; from the submaxillary ganglia filaments uniting with the chordæ tympani and lingual nerves; and from Ribes's ganglia the nerves which form the plexuses surrounding the anterior cerebral arteries.

The ganglia of the neck are the superior, middle, and inferior cervical ganglia. Numerous filaments establish a communication between them as well as with the ophthalmic, spheno-palatine, cavernous, otic, and Ribes's ganglia; and with the sixth, par vagum, glosso-pharyngeal, and ninth nerves, with the phrenic and all the cervical spinal nerves, and with the cardiac ganglion of the chest.

The ganglia of the chest are, the cardiac ganglion and twelve thoracic (on each side), united by nume-

rous twigs with each other, with the cervical, lumbar, and semilunar ganglia, with the pneumogastric nerves, and with the anterior branches of all the spinal dorsal nerves.

The ganglia of the abdomen are the semilunar and five lumbar ganglia (on each side). The semilunar ganglion, together with the pneumo-gastric nerves, forms the solar plexus, whence radiate the following secondary plexuses: the phrenic, cœliac, with the coronary, hepatic, and splenic plexuses, the superior and inferior mesenteric, the renal and spermatic plexuses. The lumbar ganglia communicate with each other by numerous filaments, with the anterior branches of the spinal lumbar nerves, with the dorsal and sacral ganglia, and form plexuses around the abdominal aorta.

The ganglia of the pelvis are four pair, and the ganglion impar. They communicate together by means of filaments, and with the anterior branches of the spinal sacral nerves, as well as with the lumbar ganglia: and they assist in forming the hypogastric plexuses. The whole of the ganglia are thus connected together as well as with the cerebral and spinal systems, while their nerves are distributed to all the organs of nutrition and generation.

The structure of the ganglia is another subject of great importance in the investigation of their functions. H. Cloquet describes them as small nervous centres, from the circumference of which proceed filaments which anastomose with the neighbouring nerves, or lose themselves in the tissue of their

organs. They invariably present themselves under the appearance of small reddish, or grayish bodies, always deeply situated in the midst of cellular tissue, destitute of any particular envelope, and varying considerably in form and magnitude. Their tissue is soft and spongy; and was, by Scarpa, thought to be composed of a multitude of nervous filaments. Cloquet adds, that the filaments which emanate from ganglia adhere to them, without appearing to be a continuation of their substance; and that some of them are white, composed of fibrils like the encephalic nerves, and surrounded with a neurilemma, while others are reddish or gray, not fibrous, and destitute of neurilemma. Müller says, "It is well known that the fasciculi of nervous fibres in the sympathetic nerves have for the most part a grey aspect, while those of the cerebro-spinal nerves are white, though the latter nerves also contain some few gray fasciculi mingled with the white; and in many parts of the sympathetic nerve there are white fibres mingled with the gray fibres. Remak has seen both white and gray fasciculi in portions of the symphathetic nerve taken from various regions; the white fasciculi are probably motor and sensitive fibres derived from the cerebro-spinal nerves, while the gray are destined to rule over the organic functions." "By the microscopic examination of the radicle fasciculi derived by the ganglionic nerve from the spinal nerves, it is learnt that they consist of cylindrical fibres, similar to those which compose the spinal nerves themselves;

the tube and its contents are as easily distinguished. These fibres are, however, more minute in their whole course in the ganglionic nerves than they are in the spinal nerves; and they are of more delicate texture, and hence more prone under pressure or distension to form varicosities; but when they have suffered no mechanical violence, they are never varicose. The peculiarity of the sympathetic seems to consist merely in the mode in which it assembles its radicle fibres and again distributes them in the peripheral direction. The radicle fibres run for a certain extent in the principal cord of the sympathetic before being given off in branches, and thus is produced an apparently continuous cord from the cervical ganglion to the coccygeal ganglion. There are, however, no facts to justify the conclusion, that the fibres are actually continued throughout the whole line. They leave the longitudinal cord in the same order as they enter it, the first forming the cardiac nerves, the next the splanchnic, and so on." Müller concludes that the ganglionic system receives motor and sensitive fibres, both which are white, from the cerebral and spinal nerves, while it transmits to them the gray or organic fibres of which he supposes the ganglia to be the roots.

Spurzheim remarks, "that ganglions are bodies composed of the two nervous substances, the white, or fibrous, and the gelatinous or pulpy, into which the first is plunged. The pulpy matter of the ganglions is commonly of a gray colour, of different degrees of intensity; sometimes, however, it has a

yellowish, a reddish, or a whitish cast; it is easily distinguishable from the nervous filaments which it surrounds. The fibres of the white substance anastomose repeatedly: they also cross each other frequently, sometimes in every direction, or in their course parallel with that of the nerve upon which the ganglia is formed." Lastly, Beclard found the ganglia to consist of a pulpy reddish gray, and a white medullary substance; so that, like the other nervous centres, they contain both globular and tubular matter.

II. The medulla spinalis or spinal cord occupies the vertebral canal, extending from the base of the brain into the first or second lumbar vertebra, where it terminates in those bundles of filaments which are called the cauda equina. It is an irregular cylindrical cord, of which the upper part is a thick knob, termed the medulla oblongata.

The medulla oblongata consists internally of alternate layers of gray and white matter which, according to Mayo, "have a remarkable tendency to form thin capsules containing white matter." It is contained within the skull, and is remarkable for six protuberances; the anterior of which are called corpora pyramidalia, the lateral corpora olivaria; and the posterior, which contribute to the formation of the cerebellum, are named corpora restiformia. The corpora olivaria and pyramidalia are regarded by Spurzheim as ganglia. According to Burdach, the former is constituted by the expansion of the gray

column of the spinal cord, and the latter consists of fundamental and decussating fibres.

Below the medulla oblongata, the cord is divided throughout its whole length by two grooves, the one on its anterior, the other on its posterior surface. There are also four other more superficial grooves which run parallel to those I have mentioned. Two of these commence between the corpora pyramidalia and olivaria, and the other two between the corpora olivaria and restiformia. By these four superficial grooves the cord is divided into three columns. The spinal nerves arise from the cord by two distinct roots, the one being anterior to the other; but they unite on passing through the intervertebral holes, previous to which the posterior root is swollen into a ganglion. These ganglia, however, somewhat differ in structure from those of the sympathetic; inasmuch as the nervous fibres may be more distinctly traced through their substance. The spinal cord, like the brain and ganglia, consists of both white and gray matter; the latter of which is surrounded by the former. Of these portions, Mr. Grainger conceives that the gray column and the fibres which arise from it constitute the true spinal system, while the white tracts and the fibres springing from them belong to the cerebral system. He has also shown that each spinal nerve derives filaments from both these substances.

The fibres of the spinal cord pursue a longitudinal course, and are either continued into its nerves or into the cauda equina. The cord itself is enveloped

in a peculiar membrane, which by some anatomists is regarded as a prolongation of the pia mater, in the arachnoid and in the dura mater; and its nerves are inclosed in thin membranous sheaths.

The spinal nerves send branches to the muscles of the head, neck, and trunk, to join the ganglionic system, to the viscera, and to the locomotory organs. By their union with the ganglionic nerves, they also form several plexuses; from two of which, called the cervical plexuses, arise the phrenic nerves, which proceed to the diaphragm, and the external respiratory nerves, which passing to the outside of the chest are distributed to the serrati magni antici and to the assistant respiratory muscles. In addition to those which are commonly called spinal nerves, Dr. M. Hall says that the trifacial, pneumogastric, and spinal accessory belong to this system. He also considers the tubercula quadrigemina as appendages to it; and Mr. Grainger includes in the spinal system all the cerebral nerves except the olfactory.

III. The brain consists of three parts, namely, the cerebrum, the cerebellum, and the pons varolii; the first of which is situated superiorly and anteriorly; the second, posteriorly and inferiorly; and the third is placed in the centre.

The cerebrum is divided into a right and left hemisphere, each of which is subdivided into an anterior lobe, a middle lobe, and a posterior lobe. In man the convolutions of the cerebrum are far

deeper, and its size is much larger in proportion to the rest of the nervous system, than in any other animal.

The cerebellum is not convoluted like the cerebrum, but its surface is lamellated or furrowed; it is divided into two hemispheres, and it presents on its fore and middle part an elongated protrusion, called the superior vermiform process, which is formed by the reciprocal crossing of the laminæ that compose the hemispheres. On the inferior surface of the cerebellum is situated the inferior vermiform process, which is composed of parallel transverse laminæ.

In the cerebellum, the white matter, which as in the cerebrum is enveloped by the gray substance, is distributed somewhat in the form of a tree, and has hence acquired the appellation of arbor vitæ. It also contains a ganglion called by Spurzheim corpus rhomboideum.

The pons varolii lies between the cerebrum and cerebellum, with both of which it is connected; its shape is quadrilateral, and it is marked along the median line by a broad groove. There are superiorly and posteriorly to its surface four tubercles, which are white externally and gray internally, and are called tubercula quadrigemina. All the other parts of the brain consist of gray matter externally; and either pure white or white intermingled with gray internally.

The brain appears to be formed by layers or masses of gray matter and bundles of white fibres which proceed from the spinal cord.

As I presume that no one would commence the study of any branch of physiology without having previously acquired some knowledge of anatomy, it will be sufficient for my purpose to give a brief account of the course which these fibres pursue when they have entered the brain, without minutely describing its anatomy. The researches of anatomists, and especially of Solly and Burdach, seem to show that the white fibres of the anterior columns of the spinal cord, which in its lower part lie parallel to each other, on arriving at the medulla oblongata divide into several sets. One set crosses the surface of the cord immediately below the corpora olivaria, and probably decussates with its fellow of the opposite side. Another set takes a similar direction, but runs to the inner side of the corpora olivaria, and then ascending to the cerebellum, forms the outer part of the corpora restiformia; while a third set, consisting of fibres from the corpora pyramidalia, passes from the inferior part of the crura cerebri, through the pons varolii into the corpora striata, and terminates in the convolutions of the cerebrum.

The fibres of the posterior column of the spinal cord may be divided into two sets. One set forms a portion of the corpora restiformia, and ascends to the cerebellum, on the way to which some of its fibres are interlaced with those of the anterior column. The other set transmits some fibres to the cerebellum, passes along the outer side of the corpora olivaria into the pons varolii, and thence to

the thalami nervorum opticorum, forming on its way a part of the crura cerebri.

From the outer side of the thalami nervorum opticorum, these fibres spread in every direction, and terminate in the convolutions of the brain. The corpus callosum, the pineal gland, the several commissures, and the pons varolii, afford the means by which the various parts of the organ are connected with each other. The gray matter of the spinal cord passes through the medulla oblongata, the pons varolii, and the optic thalami, and terminates in the corpora striata. That of the crura cerebri communicates with the gray matter of the tuber cinereum, and of the locus perforatus anticus; and thus with the convolutions of the anterior and middle lobes.*

The cerebral nerves are cylindrical cords for the most part composed of white matter, though it is frequently mingled with the gray. They are either distributed to the organs of sensation and voluntary motion, or terminate by anastomosis with each other, or with the spinal or ganglionic nerves.

The following nerves are commonly assigned to the cerebral system, but to many of them the spinal system may lay an equal claim, and all of them as well as all the spinal nerves, according to Müller, contain ganglionic fibres.

The first pair, or olfactory nerves, arise by means of three roots, one of which consists of gray matter,

* See Grainger on the Spinal Cord.

and the other two of white, from the bottom of the fissura sylvii, from the corpus callosum, and from the posterior part of one of the anterior inferior convolutions of the brain, and are distributed to the lining membrane of the nose.

The second pair, or optic nerves, arise by a broad white fibrous band from the anterior quadrigeminal bodies, receiving at right angles filaments from the corpora geniculata, and from the tuber cinereum. The nerves thus formed unite on the anterior part of the pituitary fossa; but whether they cross each other, so that the left nerve passes to the right and the right to the left, is a point still under dispute. Gall and Spurzheim recognize a partial decussation of the fibres; they believe that the outermost filaments continue their course without decussating. The optic nerves terminate by forming the retina.

The third pair, or motores oculorum, arise from the locus niger of the crura cerebri, and from that part of its white substance which is a continuation of the anterior column, or motory tract of the spinal cord, and they terminate in the muscles of the eye and in the iris.

The fourth pair, or pathetic nerves, arise by three filaments from the inferior quadrigeminal bodies, from the valve of Vieussens, and from the processus a cerebello ad testes, and are distributed to the superior oblique muscle of the eye.

The fifth pair, or trifacial nerves derive their origin from both the anterior and the posterior

columns of the spinal cord; and pass out of the pons varolii in two portions. The larger portion, which in addition to its other roots is also attached at its commencement to the gray matter of the medulla oblongata, on emerging from the pons varolii, swells so as to form what is called the Gasserian or semilunar ganglion, and afterwards separates into three divisions, while the smaller portion passes under the ganglion, and afterwards joins the third division of the larger portion.

This nerve is distributed to the muscles of the face, the membrane of the nose, the eye, the tongue, the palate, the teeth, &c. &c., and it also anastomoses with the ganglionic nerves.

The sixth pair, or nervi abducentes, arise from the corpora pyramidalia, and from the gray matter of the medulla oblongata, and are distributed to the abductor muscles of the eye.

The seventh pair, or portio dura of the seventh, as it is commonly called, arises from the corpora restiformia, corpora olivaria, and the anterior tract of the spinal cord, and according to Grainger, from the gray matter in the interior of the pons varolii. Each nerve then passes between the corpora pyramidalia and olivaria, and is distributed to several of the muscles of the face.

The eighth pair, or portio mollis of the seventh, arises from the floor of the fourth ventricle. These nerves emerge from the medulla oblongata in front of the corpora restiformia, and are distributed on the membrane lining the labyrinth of the ear.

Mayo remarks that the fibrils in which they commence coalesce at the median line; so that the root of the nerve on one side is connected with that of its fellow, in a manner resembling the junction of the innermost fibres of the two optic nerves; the optic and auditory being the only nerves which convey a *single* impression when both eyes or both ears simultaneously receive impressions.

The ninth pair, or glosso-pharyngeal nerves, upon each of which there is a ganglion, arise from the corpora olivaria, and are distributed to the muscles of the pharynx, and to the tongue.

The tenth pair, pneumogastric nerves or par vagum, upon each of which there is a ganglion, arise from the corpora olivaria, and are distributed to the pharynx, larynx, to the lungs, diaphragm, stomach, liver, duodenum, spleen, kidneys, and other viscera. They also anastomose with the ganglionic nerves.

With this pair of nerves are also usually associated the spinal accessory nerves, which, arising by several fibrils both from the medulla oblongata and the upper and posterior part of the spinal cord, send twigs to the pneumogastric nerve, the pharynx, and the muscles of the neck.

The eleventh pair, or hypoglossal nerves, arise from the corpora pyramidalia, and according to Grainger, from the gray matter on the inner side of the corpora olivaria, and are distributed to the tongue and the muscles connected with it.

With the exception of the first pair, each of these

nerves is inclosed in the peculiar membrane which is called the neurilemma or nerve coat, whereby the fibres are bound together. The brain is enveloped in three membranes, namely, the dura mater, by which the brain and spinal cord are supported and retained in their position; the tunica arachnoides, which prevents friction between the other membranes by lubricating their surfaces; and the pia mater, which supports the external vessels of the brain.

The pia mater is supposed also to secrete the serous fluid which is found between itself and the arachnoid on the surface of the brain, in its ventricles, and between the arachnoid and the proper membrane of the spinal cord; though it would seem equally probable that this liquid is secreted by the arachnoid. By filling up the crevices between the irregular masses of nervous matter, and the smooth cavities in which they lie, this fluid enables the membranes to sustain with equal pressure every part of the brain and spinal cord, on the principle of the hydraulic bed. The brain is, moreover, defended from external injury by the skull, as the spinal cord is by the vertebral canal.

The sketch which I have given of the anatomy of the nervous system, although imperfect, will, I trust, afford a sufficiently correct idea of its various parts, and of their connexion with each other, to enable me to explain its physiology.

It is of great importance to keep in mind the internal structure of the nervous system, as the offices of its various parts depend upon the direction and connexion of the nervous tracks and fibres.

CHAPTER V.

OF THE ACTION OF NERVOUS MATTER.

Some physiologists have supposed that the living brain has a peculiar movement which is necessary to the performance of its functions; but there is no proof of any such necessity.

Nevertheless, two distinct motions are discernible in animals in whom this organ has been exposed, as well as in some infants, and in persons who have lost a portion of the skull from disease. One of these movements is synchronous with the pulsation of the arteries by which it is caused, and the other seems to be consequent on respiration, for at each inspiration the brain apparently contracts, and again expands during each expiration.

No pain is inflicted by puncture or laceration either of the cerebrum or of the cerebellum; and very little by mutilation of the tubercula quadrigemina; but the posterior column of the spinal cord is extremely sensitive. So likewise the nerves arising from the posterior column of the spinal cord, together with the optic, olfactory, trifacial, auditory, glossopharyngeal, and pneumogastric, afford unequivocal indications of sensation; whereas, others may be cut or pricked without producing pain, but

the part to which they are distributed is thereby paralyzed or convulsed.

If the spinal cord be divided, the parts below the incision are paralyzed; if the medulla oblongata be cut through, death ensues; but animals have been known to live several months after the cerebrum and cerebellum have been removed. Mutilation, either of the medulla oblongata or of the spinal cord, is followed by spasms and convulsions on the *same* side as the lesion inflicted; mutilation of the cerebrum, corpora striata, optic thalami, or of the cerebellum is succeeded by paralysis of the opposite side. Partial injury of the corpora quadrigemina causes blindness of the eye and spasm on the opposite side of the body. This cross action is explained by the decussation of the fibres of the corpora pyramidalia, of the corpora quadrigemina, and of the optic nerve.

No pain is produced in the ganglia and their nerves either by galvanism or by mechanical stimuli, but both these irritants have been observed to excite convulsions of the parts to which ganglionic filaments are distributed.

It is a notable fact, that, although the power of exciting the action of the internal organs and of causing contraction of the muscular fibre is, equally with sensation, a property of nervous matter, yet it never exerts this faculty except when under the influence of stimulant impressions, whereby its latent energies appear to be awakened. When these excitants are withdrawn from the cerebral system the

result is sleep; but death ensues, if either the ganglionic or the spinal system be deprived of them even for the space of a few minutes.

The respective offices of the gray and of the white matter of the nervous system is a subject which has been much discussed. Dr. Hartley imagined that the white medullary substance was the instrument of the sensations and mental faculties; while Gall and Spurzheim thought that both the gray and white matter were necessary to produce an instrument adequate to perform each particular function; but that the principal use of the former was to secrete the latter.

Dr. Spurzheim says, "seeing that the rudiments of each new shoot in trees are developed in a deposition of mucilaginous looking matter; that the cartilages in animal bodies are successively liquid, gelatinous, and cartilaginous, and that several turn into bone; that anatomists in many instances have agreed in deriving the nerves from ganglions; that the brain too is at first fluid, then gelatinous, and ultimately fibrous; in fine, that the pulpy (gray) nervous substance is always found where the white fibres become more numerous; that these are implanted, so to say, into it, and that a great quantity of blood-vessels are expanded in it—Dr. Gall and I have said that to us it appears to be the source or nourisher of the white fibres."

In opposition to this opinion, Foville and Pinel Grandchamp maintained that the superficial gray substance of the brain is the instrument of the in-

tellectual functions; and that the white and deep-seated gray matter preside over locomotion.

According to another modification of this theory, which is held by many eminent physiologists, and is advocated by Mr. Grainger, the white fibres are subordinate to the gray matter, which is the sole source of power, or, in the words of Mr. Solly, "the peculiar power of the nervous system resides in the cineritious portion, and the office of the medullary is simply that of a conductor."

It is argued in support of this view of the subject, that the white matter appears before the gray; that there is no evidence to show that the white fibres are derived from the gray matter; and that it is probable both are secreted by the membranes in which they are enveloped; that the gray matter is the more vascular, and therefore the more energetic; that it increases in quantity in the exact ratio of the nervous energy; and that it is only met with in those parts of the nervous system which are known to be the seat of power, such as the roots of nerves.

From these facts it has been inferred that the gray substance may be regarded as the seat of nervous influence, and the white matter as only the conductor of sensible impressions and of volition. Hence it would follow that the gray substance of the brain is the true centre of the cerebral system; that of the spinal cord, of the spinal system; and that of the ganglia, of the ganglionic system: these nervous centres being reservoirs of the nervous

principle, and forming the connecting links between the sensiferous and the motory nerves, which are merely conductors of impressions, and which owe their excitability to the central masses to which they are attached.

It appears to me, however, much more likely that the nervous power is the product of the combined action of both the substances, and could not be generated by either of them alone. The globular and tubular portions of the nervous system may be compared to the two metals of a Galvanic battery, the former being acted upon by the animal fluids and other nervous stimulants, and the latter by the acid.

All the nervous centres contain both kinds of neurine; and though the tubular matter is certainly a conductor of sensible impressions, and may be excited by electricity, even when it is detached from the globular matter, yet the nervous power is never naturally exerted, except the two be in contact with each other.

Nothing, however, is decidedly known respecting the action of nervous matter for it has hitherto defied every investigation; but since much ingenuity has been expended on this subject by men of the highest talents, I shall mention a few of the most famous hypotheses.

Until the middle of the 17th century, it was very generally supposed that an impression at the extremity of a nerve was conveyed to the brain by means of a fluid with which the nerve was filled.

Descartes,* who held this opinion, says that the mind has its seat in a gland at the middle of the brain, which contains the animal spirits, so that when this spirit is set in motion by any sensible objects, the mind is affected, while on the other hand, by the action of mental impressions upon this medium, the movements of the muscles are excited and controlled.

To this explanation of the action of nervous matter, succeeded the doctrine of vibrations which was first suggested by Sir I. Newton, in the two last sentences of his Principia.

"And now," he remarks, "we might add something concerning a certain most subtile spirit which pervades and lies hid in all gross bodies; by the force and action of which spirit, the particles of bodies mutually attract one another at near distances, and cohere if contiguous; and electric bodies operate to greater distances, as well repelling as attracting the neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies: and all sensation is excited, and the members of animal bodies move at the command of the will, namely, by the vibrations of this spirit, mutually propagated along the solid filaments of the nerves, from the outward organs of sense to the brain, and from the brain into the muscles. But these are things that cannot be explained in a few words, nor are we furnished with that sufficiency of experiments

* De Passionibus, Part I. Art. 34.

which is required to an accurate determination and demonstration of the laws by which this electric and elastic spirit operates."

Upon the hints which Newton has given in the foregoing passage, and in the questions annexed to his optics, Dr. Hartley founded his celebrated theory, which was published in the year 1749. He supposed that "external objects impressed upon the senses occasion first in the nerves on which they are impressed, and then in the brain, vibrations of the small, and, as one may say, infinitesimal medullary particles," which "are excited, propagated, and kept up, partly by the ether, i. e. by a very subtile and elastic fluid, and partly by the uniformity, continuity, softness, and active powers of the medullary substance of the brain, spinal marrow, and nerves."* He imagined that the vibrations differ in degree and in kind, according to the varieties of our simple ideas, and thus he endeavoured to explain the association of ideas, and the mode in which complex ideas are formed.

Cabanis, on the other hand, compares the operations of the brain to those of the glands and stomach, and, without enquiring into the causes of its action (though he seems to think that the nervous power is somewhat analogous to electricity), is content with regarding the brain as the secretory organ of thought.

"To form a just idea," he says, "of the operations

* Observations on Man.

from which thought results, we must consider the brain as a peculiar organ specially designed to produce it; in the same manner as the stomach and the intestines perform the office of digestion; the liver that of filtrating the bile; the parotid and the maxillary and sublingual glands, that of preparing the salivary juices. Impressions when they reach the brain give it a greater activity, as aliment falling into the stomach excites it to a more abundant secretion of the gastric juice, and to those movements which favour its solution. The proper function of the one is to collect each particular impression, to attach meaning to it, to combine different impressions, to compare them together, to form from them judgments and determinations; as the function of the other is to act upon the nutritious substances by whose presence it is stimulated, to dissolve them, and to assimilate the juices to our nature.

"Will any one say that we are ignorant of the organic movements by which the functions of the brain are executed? The action by which the nerves of the stomach determine the different operations constituting digestion, and the manner in which they impregnate the gastric juice with the most active dissolving properties, are no less concealed from our researches. We see the aliment fall into this viscus with new qualities; and we conclude that it has thereby been made to undergo this alteration. We equally remark that impressions reach the brain by means of the nerves, in a simple and unassoci-

ated state; but when the organ commences its operation upon them they are soon metamorphosed into ideas, which the languages of physiognomy, of speech, or of writing manifest. With the same certainty we conclude that the brain in some degree forms the impressions, and that it organically causes the secretion of thought."

Cabanis's explanation, however, merely amounts to an assertion that ideas are received through the senses and associated in the brain, which is the organ of mind, while he leaves the question respecting the nature of the nervous power, very much where he found it.

It is an observation of Cuvier* that volition produces the contraction of the muscular fibre, through the medium of the nerves, and that all contraction, and generally speaking every change of dimension in nature, is produced by a change of chemical composition, though it consist merely in the flowing of some imponderable fluid, such as caloric; and that there is consequently good reason to suppose that the nerve acts upon the fibre through the medium of an imponderable fluid.

There does certainly appear to be sufficient ground for believing that the nervous system is the vehicle of some such principle; which in many of its phenomena bears a striking resemblance to electricity. It has been shown by many ingenious physiological experiments that galvanism is, for a

* Règne Animale.

time at least, capable of sustaining the physical functions of the nervous system; indeed, its action on a nerve of voluntary motion is precisely similar to that of the brain, except that in the one case, the impulse is received from the machine, in the other from the mental emotions; and their respective influence on the animal secretions displays a singular analogy between them. The effects of galvanism on the ganglionic nerves is not however so powerful as on the cerebral nerves; affording a curious proof that sensation and electricity are alike modified by the slightest difference of organization. Nor is there any reason why that which can give impulse to a motory nerve, may not also impart energy to a sensiferous nerve.

I do not mean to assert that nervous influence and electricity are absolutely identical; but it is surely far from impossible that the former may be a subtile modification of the latter. May not the same principle which can impart magnetism to unorganized bodies give sensation to those which are most highly organized? Chemistry and other branches of physics have already afforded a most satisfactory explanation of many of the corporeal functions, and there is nothing in the structure of the body, whereof every part is a combination of the same elements which compose inorganic substances, to forbid the supposition that both animate and inanimate nature may be regulated by the same fundamental laws.

Of all the physical agents with which we are

acquainted, the electric principle is the most universal. It is contained in almost every vegetable and mineral; it has been detected in the earth, and attracted from the clouds; it pervades the atmosphere in which we live, and affects the health as well as the diseases of man. Moreover its existence in all animals has been clearly proved; and some have peculiar electrical organs. In a series of experiments made by Faraday on the gymnotus electricus or electrical eel, it appeared that the animal could produce the same results as an electrical machine. Decomposition was effected by it, electric sparks were elicited, the galvanometer affected, the magnetic influence communicated, and the temperature of wire raised. In the torpedo we observe a galvanic apparatus which is supplied with numerous nerves, and affords the means of self-defence, while in beings of a much higher order galvanism is both capable of altering the secretions, and of producing powerful muscular contraction, not only during life, but after death. It has been also shown by Pfaff and Ahrens,* that excitable persons contain more free electricity than indolent persons; that the quantity of electricity in the human body is greater in the evening than at other periods of the day, and is increased by spirit drinking; that bodies which are very cold evince no electricity, but gradually manifest it as warmth is restored; and that during rheumatic affections the electricity is reduced; but it is again augmented as the disease subsides.

* See Müller's Elements of Physiology.

No electric currents, however, have been discovered in the nerves; and it has been found that when a nerve is divided or tied with a ligature, the electric fluid is transmitted as easily as before, while the passage of the nervous principle is in either case interrupted. It is nevertheless evident that the electricity which is developed in animal bodies is connected with the nervous action; for if the brain of the torpedo be destroyed, or the nerves which supply its battery be divided, the power of giving the electric shock ceases; while it continues some time after the heart has been removed.

Upon the whole, notwithstanding the resemblance which the functions of the nervous system in many respects bear to electrical phenomena, it is perfectly evident that no theory which has yet been promulgated explains the instrumentality of the brain in the workings of the human mind, or how the impressions which are conveyed by the sensiferous nerves to the cerebrum are associated, so as to assume new forms, and create new ideas. But happily our ignorance on this point is of very little importance, either to the physiologist or the metaphysician, though a matter of curious research; for while we may be permitted to speculate on the "nervous fluid," the "electric fluid," or the "etherial fluid," it is sufficient for all philosophical purposes that nervous matter be recognized as the material organ or seat of sensation, instinct, and intellect, and the excitor of the animal motions.

CHAPTER VI.

OF NERVOUS STIMULANTS.

It was stated in the last chapter that the nervous matter does not exhibit its active faculties, except when under the influence of stimulant impressions; and before we proceed to consider the several kinds of sensation, I shall say a few words on the circumstances whereby this excitement is produced.*

The nervous stimulants comprise most of the objects which affect the senses, and are supplied by the elements of the body itself, as well as by the various principles of which inorganic substances are composed. Food, arterial blood, animal heat, and electricity, all the secretions and all the excretions may be numbered among the internal stimuli.

The external stimuli are still more numerous, including air, light, sound, mechanical irritants, heat, cold, moisture, and atmospheric electricity; the influence of all which is sufficiently obvious. Thus heat, by stimulating the nervous system, increases the frequency of the pulse, excites the

* On this subject see Dr. Fletcher's Rudiments of Physiology.

secretion of perspiration, and imparts energy to all the functions. Hence it happens that, at the approach of spring, the quadrupeds, insects, and reptiles, which lie dormant during the winter, are awakened from their deathlike sleep, crawl into light, and resume their place in the living world.

For the same reason, heat is frequently very beneficial in restoring those who have been found in the act of drowning, and that too, even when animation has been for some time suspended. The inhabitants of warm climates possess much more sensibility than those of the colder regions; and warm-blooded animals are more sensitive than those in which the blood is cold. Cold however, paradoxical though it may seem, is also a stimulant to the body in its natural state, as the invigorating effect of a frosty morning, the cold bath, &c. clearly prove; but, like many other stimuli, the secondary action of cold as well as of heat is decidedly sedative; for warm climates debilitate, and long exposure to cold produces an inclination to sleep.

The remarkable power of electricity on the body, scarcely requires notice, as it is manifestly the result of its stimulating property. To this may be attributed the headach and pains in the limbs which storms of thunder and lightning so often occasion. The electrical stimulus, moreover, exerts a very peculiar action on the dead body, when applied to it by means of a galvanic battery; and

during life, like most of the other stimulants, it possesses the faculty of exciting in each of the several organs of sense, the sensations which are proper to it. Thus, if the tongue be placed between a plate of silver and one of zinc, a peculiar taste is experienced; in the ear a galvanic shock creates a sonorous impression; while to the eye, an electrical current presents the appearance of a stream of light: the latter of which phenomena Müller explains by the hypothesis that "the sensation of light in the eye thus produced is not a development of the matter of light, but is merely the reaction of the optic nerve which is susceptible of the sensations of light and colours only, not of pain. It is a peculiar state of the optic nerve, just as pleasant and painful sensations are peculiar states of the nerves of common sensation." This explanation, however, is by no means satisfactory, nor is the comparison very apt; for, as I shall hereafter show, pleasure and pain are dependent upon the *degree* of sensation, and not upon any peculiar affection of the nerves.

The action of the brain is excited by any of the stimuli which come in contact either with the sensitive portions of the organ itself, or with its sensiferous nerves, though more powerfully by external than by internal impressions. Hence, although sleep be disturbed, yet it often continues while the viscera are in a most irritable state; but a strong glare of light or a loud noise is at all times totally incompatible with repose, and during

attacks of delirium or of insanity usually aggravate the disease by exciting the imagination as well as by calling forth the physical energy of the brain. In like manner, all other objects which affect the brain through the senses, more or less increase its activity, while all, moreover, contribute to the intellect; for the mind can only receive information by these channels, and its vigour must decline unless it be from time to time supplied with new ideas.* Thus, persons in solitary confinement, to whom neither the use of books nor communication with their fellow-creatures is permitted, and who have no object to contemplate except the walls of their prison, speedily begin to lose their faculties and display mental imbecility.† Memory, by recalling past sensations, may indeed for a time sustain the intellectual powers; and the internal impressions, which are less intermittent though likewise less powerful than the external, contribute their aid; but of these sources, the former soon

* The Abbé du Bos in his Réflexions critiques sur la Poësie et sur la Peinture remarks that "L'ame a ses besoins comme le corps, et l'un des plus grands besoins de l'homme est celui d'avoir l'ésprit occupé. L'ennui qui suit bien-tôt l'inaction de l'ame est un mal si douloureux pour l'homme, qu'il entreprend souvent les travaux les plus penibles afin de s'épargner la peine d'en être tourmenté." To this necessity for mental excitement, the Abbé attributes the fondness of the ancients for the exhibitions of gladiators, and that of many persons even in our own times for witnessing public executions and other painful spectacles

† At the taking of the Bastile during the first French revolution, of seven prisoners found in that dungeon of despotism, three had lost their reason, having been detained there from the days of Louis XV.

fails, unless the store of ideas be renovated by a regular influx of new objects, and the latter alone would scarcely raise the faculties above idiocy.

The stimulant influence of the passions is also deserving of notice; but to this subject, I shall hereafter allude, both in speaking of sympathy and of the sensations.

CHAPTER VII.

OF THE GENERAL LAWS OF SENSATION.

SENSATION* is the perception of the impressions, which inorganic as well as organized substances produce upon animal bodies; and though most physiologists as well as metaphysicians, have employed the word *sensation* to signify *mental* sensibility alone, throughout the following pages it is always used in the more extensive signification of which it in reality admits.

A nerve, as I shall hereafter more fully explain, may be sensible of the impression of a stimulant, so that the organs with which it is connected shall be called into action without any mental consciousness; which indeed must be the case with all those fibres which belong to the spinal or ganglionic systems, and do not anastomose with cerebral nerves; for the mind cannot perceive any object unless it be communicated to the cerebrum.

There are, therefore, two kinds of sensation: the one of which is unaccompanied with consciousness, and which, for the sake of distinction, we

* The best accounts of the laws of sensation are given by Cullen and Müller; but their observations are confined to positive sensation.

shall call *negative* sensation; while the other which is attended with consciousness, we shall name *positive* sensation. No physical difference, however, exists between the two species of sensation; for whether the nerve be alone sensible of the stimulant which is acting on it, or whether the cognizance of the intellectual faculties be also aroused, the operation on the nervous matter is of the same kind and only differs in its effect.

Sensation is entirely dependent on the nerves, as both physiological and pathological observations clearly demonstrate; and it is regulated by certain laws, which are equally applicable to the perception and transmission of every species of impression that may affect the nervous matter.

The objects which act upon the senses in the natural manner do not come into immediate contact with the nervous matter, but reach it through some medium which is adapted to receive the impression, and to concentrate its force upon the nerve. The eye, the ear, the skin, and the internal membranes are suited to perform this office, and by their mechanism render the perceptive faculties minutely accurate. No sensation can arise in a part which is disorganized, or can be transmitted to other parts, unless the nervous communication be perfect. Thus the perception of light may be destroyed either by letting out the humours of the eye, or by dividing the optic nerve. In the first case the receptacle of the rays is obliterated; in the second the channel of transmission is cut off.

The union of two nerves does not, like that of arteries, enable them to assist each other. If only one of two nerves which anastomose be divided, the part to which it is distributed becomes paralysed; for the uninjured nerve does not supply nervous power to the branches of the other. It cannot do so, because the fibres of one nerve do not form a continuous channel with those of another, although they be bound together by the same neurilemma.

Sensations are modified by age, by the state of the atmosphere, and by that of the circulation and other functions. Inflammation increases, and extreme cold diminishes the acuteness of sensations. In youth they are active; in old age they decline.

The intensity of sensations varies according to the force of the impressions by which they are produced. For instance, those combinations of sounds which constitute music or harmony commonly excite agreeable and soothing sensations, while the report of a gun which is fired close to the ear is extremely painful and agitates the whole frame. So with regard to the eye, a moderate degree of light is pleasant, but an intense glare is painful. The same principle is also exemplified by the other senses. Food may be too sweet, or too acid; substances may be too hot or too cold; and even the most agreeable scents may become so powerful as to cause faintness or convulsions. Upon the various modifications of the positive sensations depends their power of exciting either agreeable or painful feelings. The spasms which arise

from the application of artificial stimuli to the spinal nerves show that the negative sensations are likewise subject to this law, inasmuch as they vary according to the intensity of the impressions which excite them.

All impressions on sensiferous nerves have a tendency to exhaust their power. Thus an intense light deprives the eye of its sensibility to more obscure objects, and the habit of eating highly-seasoned dishes renders the nerves of the taste insensible to plain food. The diminution of sensibility and slowness of the pulse which are consequent on the action of powerful stimulants, and the failure of medicines, such as narcotics and cathartics, to produce their wonted effect when they have been frequently used also illustrate this law; for, in the latter instance, the enfeebled movements of the internal organs as much result from torpidity of the nerves of negative sensation as, in the former, dimness of sight does from weakness of the optic nerve.

When two impressions are made simultaneously, the more feeble sensation merges in the more powerful one and is not perceived. If, for example, the spinal cord or its nerves be artificially irritated they cease to be affected by the natural stimuli, and the organs which are dependent on them become convulsed. So likewise a man undergoing an operation, or under the influence of strong mental excitement is not sensible of minor impressions. A most singular instance of this occurred at the battle of Thrasymene, during which the attention

of the combatants was so completely absorbed that they did not feel an earthquake that took place at the time, and was so violent as to overthrow many of the cities of Italy, to turn the course of rapid rivers, and even to tear down mountains.

Sensations remain a certain time after the circumstances by which they may have been caused have ceased to operate upon the body. This is illustrated by Sir Isaac Newton's well-known experiment with the burning stick; by the continuance of convulsions arising from sudden fright long after the cause of fear has been removed; and by the sobbing, even during sleep, of children who have had a violent fit of crying.

The nature of the impressions which a nerve transmits depends either upon the peculiar structure of the nerve itself; upon the sensitive organs to which it is attached, or upon the nervous centre in which it terminates. Hence some nerves are only susceptible of one set of impressions. Through the medium of the eye the optic nerve is sensible of light, while its structure is such that it may be cut or pricked without manifesting sensation. There are in this instance two causes of peculiar sensation; and the third may be illustrated by comparing the three systems of nerves: those of the spinal system and of the ganglia being conductors of negative sensations, whereas all the sensations of cerebral nerves are of the positive kind.

Impressions are transmitted in a longitudinal direction either from the extremity of the nerve to

its centre or from the centre to the extremity. This is inferred from the arrangement of the primitive nervous fibres which, as I have already stated, lie parallel to each other: because when the trunk of a nerve is irritated throughout its whole diameter irritation is produced in all its branches; whereas, if one side of it, or a single branch alone, be irritated, the sensation excited is confined to those parts to which the affected fibres are distributed: and because when the extremity of a nerve is irritated its nervous centre is thereby stimulated.

Besides the foregoing laws, which are common to both kinds of sensation, the positive sensations have likewise other laws which are peculiar to themselves, and which will be hereafter mentioned.

CHAPTER VIII.

OF NEGATIVE SENSATION.

THE negative sensations are the result of impressions on nerves, which are not *immediately* connected with the brain, and therefore can communicate no ideas to the mind; for since the cerebrum is alone the seat of the intellectual faculties, there can be no mental perception of any objects except such as are conveyed to it by the nerves of which it is the centre. We are therefore only conscious of the impressions made on *cerebral* nerves, while those which affect the fibres of the ganglionic and spinal systems awake no consciousness and are only manifested by their action upon the motory organs.

Divide, for example, the upper part of the spinal cord of a frog, and if one of the feet be then pricked or irritated, the leg will immediately contract although volition can have no influence over the limb, inasmuch as its nervous communication with the brain is cut off. In this instance of negative sensation, the impression on the sensitive spinal nerve passes to the spinal cord, which being thereby called into action excites the motory nerve of the muscles of the leg. Dr. M. Hall mentions

an illustration which is still more striking, because it occurred in a person who was able to give an account of her feelings, whereas, those of the frog can only be surmised. The case to which I allude is that of a young lady who was labouring under spinal disease, and in whom tickling of the sole of the foot excited contraction of the leg, notwithstanding she was perfectly unconscious of the irritation.

I also have witnessed similar phenomena in a person who was in a most profound apoplexy, of which he died in the space of two hours afterwards.

These involuntary movements are regarded by Dr. M. Hall, as the consequence of a *reflex* action in the spinal or, as he calls it, the excitomotory system, which, according to his views, possesses properties that are peculiar to itself. This, however, is not a just distinction, for the spinal sensations are regulated by the same general laws as those of the ganglia and cerebrum. Their physiological differences do not appear to me to depend upon any peculiarities in the structure of the various nerves, but upon the organization and functions of their respective centres.

The spinal cord is merely a reservoir of nervous matter, which, when stimulated by the impressions that are transmitted to it, immediately propagates its influence along its motory nerves to the parts wherein they terminate. It is not a *mental* organ, and the mind does not, therefore, perceive the

sensations of its nerves, or control the motions over which it presides.

For a like reason, we are unconscious of the impressions which are transmitted to the ganglia, and their motory nerves are not subject to the will.

These observations, of course, only apply to the real spinal and ganglionic nerves, not to the numerous filaments of cerebral nerves which unite with them. If, indeed, we can discover in what centre the fibres of a sensitive nerve terminate, we may decidedly say whether it be a nerve of positive or of negative sensation. It is, however, by no means easy to trace the fibres after they have entered the large medullary masses, and it is useless to follow them only to the surface.

We are so little acquainted with the minute physiology of the ganglionic system, that our opinions concerning the special offices of the several ganglia and their nerves amount to little more than conjectures. Since, however, the direction of the fibres, which enter into the composition of this division of the nervous system, would lead us to believe that the gray tracks of neurine belong to the ganglia, while the white filaments, which are intermixed with them, are cerebral nerves that join but do not unite with them; it would follow that the gray fibres are the sole transmittors of impressions to the ganglia, for any object that acted upon the white fibres would pass to the brain, and create a positive sensation.

It seems, indeed, extremely probable that the action of the ganglionic system is similar to that of the spinal system, and that the ganglia possess distinct sets of sensitive and motory fibres.

The negative sensations of this system principally arise from internal stimuli. In the alimentary canal the ganglionic nerves receive impressions from the gastric and intestinal juices, the bile and the food; in the heart and arteries from the blood; and in other parts from the secretions and animal heat. These particulars, relative to the sensations of the ganlionic system, are, I think, fairly deducible from analogical facts and reasoning; but they are not proved by experiment, for so closely intermingled are these nerves with those of the spinal and cerebral systems, that observations on their sensitive faculties are inconclusive as well as exceedingly difficult.

The functions of the spinal system have been most successfully examined by Sir C. Bell,* Professor Müller,† Professor Volkman,‡ and above all by Dr. M. Hall;§ and though there may be some uncertainty respecting the precise office of individual nerves, the following are probably the most important of those which contain spinal sensitive fibres:

1st. The optic nerves, which receive the impressions and stimulus of light.

* On the Nerves.

† Elements of Physiology.

‡ On Reflex Motions; for which see Med. Chir. Review; 1838.

§ Lectures on the Nervous System.

2dly. The larger portion of the trifacial nerves, which receive impressions from the membranes of the eye and eyelid; from the nostrils, the fauces, the tongue, and the face.

3dly. The glossopharyngeal nerves, which receive the impressions of food, and of the saliva in their passage along the tongue and through the pharynx.

4thly. The pneumogastric nerves, which receive the impressions of food and the digestive secretions in the pharynx, the œsophagus, and the stomach, and of air in the larynx and in the lungs.

Dr. Marshall Hall considers carbonic acid as the stimulant to these nerves in the pulmonary organs; and adduces several striking facts to show that the ordinary act of inspiration is excited by the contact of a certain portion of the gas with the filaments of the pneumogastric nerves in the lungs. As there is however considerable difference of opinion among physiologists respecting the functions of these nerves, this hypothesis, though highly probable, is by no means thoroughly established.

5thly. The posterior spinal nerves, which receive the impressions, in the rectum, of the intestinal juices, and its other contents; in the bladder, of the urine; of the fœtus, in the uterus; and of cold, heat, air, &c. &c. on the surface of the body.

The auditory nerves, which receive sonorous impressions, may also, according to Mr. Grainger, be regarded as sensitive, or excitor nerves of the

spinal system: but this as yet wants proof. It must be remarked that most, if not all, of the sensitive spinal nerves are bound up together with sensitive fibres of the cerebral system, the consequence of which is that the impressions acting upon the former affect likewise the latter; and thus a positive and negative sensation simultaneously arise, except when the brain is either diseased or destroyed. Many, indeed, of the nerves which have been here enumerated more properly belong to the cerebral system, since they originate in the brain, and thence derive the greater part of their fibres, though they are joined by filaments from the spinal cord.

The use of negative sensation is, as we shall hereafter see, to excite the nerves of involuntary motion, and so call into action the vital organs.

CHAPTER IX.

OF POSITIVE SENSATION.

In the last chapter I endeavoured to show that the ganglionic and spinal nerves are essentially the organs of negative sensation; and for like reasons to those which I then adduced, it necessarily follows that, since the brain is the seat of intellect, those sensations which are accompanied with consciousness, and which I have called positive sensations, exclusively depend upon the cerebral system. We know that the brain is the organ of the mental faculties, because when it is injured, either by accident or disease, the powers of the mind are either impaired or destroyed; and the perception of impressions is more or less diminished. Thus, pressure on the cerebrum by effusion of blood, by depression of the skull, or by any other cause, and inflammation of its substance immediately annihilate the mental functions; and it has been observed that, although anencephalous infants in whom the cerebrum and cerebellum are wanting, and animals in which the brain has been removed, can suck and perform other instinctive acts, yet that they display no semblance of volition or reason.*

* See Histoire générale et particulière des Anomalies de l'Organization chez l'Homme et les Animaux, etc. Par J. G. Saint Hilaire.

Richerand mentions the case of a woman, in whom there was so extensive a carious affection of the skull that the greater part of the left parietal bone was destroyed, and a considerable portion of the dura mater thereby exposed. While dressing the wound, he questioned the patient respecting her situation, and she gave rational answers until he pressed the piece of lint which covered the naked brain, when she suddenly stopped in the middle of a sentence; but the respiration and pulse continued. On the removal of the pressure she did not speak, and when asked if she remembered the last question which had been put to her, she said that she did not. This experiment was repeated three times, and in each instance sensation and intellect were suspended.

Flourens removed both the cerebral lobes of a chicken; and in this state the bird lived for ten months, at the end of which time it was killed, or it might probably have survived much longer. The destruction of the cerebrum did not seem to affect its general health, but immediately deprived it of taste, smell, sight, and hearing. It stood upright; walked when irritated; flew when thrown into the air; and swallowed when water was poured into the beak; but it appeared to be stupefied, and to act according to the artificial impulse which was given to it; and not under the guidance of volition. It would remain standing in the posture in which it was placed; and never moved unless stimulated. It seemed to feel neither hunger nor thirst; for after

having fasted during three days it did not attempt to take the food which was placed before it; and was only fed by cramming. From this curious experiment we may infer that, by removal of the cerebrum, the mental faculties, and consequently the positive sensations, are destroyed; for the fluttering of the wings, when the bird was thrown into the air, may have been merely an instinctive action; and without more evidence, of which the other phenomena afford none, it is certainly insufficient to prove the existence of volition.

The same remark is equally applicable to the experiments of Magendie and Desmoulins, who found that when the cerebrum and cerebellum were cut away, the animal on being irritated on the face and nose cried and attempted to remove the cause of irritation with its paws. Magendie, moreover, relates the case of a gentleman who, when labouring under affection of the brain, lost the control over the locomotive organs; and yet he never fell, but always preserved his equilibrium. At certain times his motions would pass into the train of ordinary actions; so that without the least participation of his will, he was seen to rise and walk with rapidity until he met with a solid body that opposed his passage; and sometimes to walk backwards till he was stopped by a similar obstacle. In this case, the voluntary motions were excited by the morbid irritability of the brain which overcame the power of volition, but in the other instances which I have adduced, the movements were probably effected by

means of the spinal system which, as we know, would necessarily be called into action by the application of a stimulus.

The experiments of Flourens are corroborated by similar ones which were performed by Hertwig, on dogs and pigeons, and were attended with like results.

If, however, these were the only proofs that the brain is the seat of the mind, some perhaps might hesitate to adopt such an opinion; but the large size of the cerebrum in man, compared with that of other animals, and the symptoms of cerebral disease, leave no doubt upon the subject.

We are told by Cuvier, whose observations have been confirmed by subsequent investigations, that the intelligence of animals is more perfect in proportion to the size of the cerebrum, and that in man, this part is larger, more extended, and more convoluted than in other creatures. In proportion as we descend from man, we observe that it becomes smaller and smoother on the surface, and that the parts of the brain are less complicated with each other, but seem to be unfolded and spread out longitudinally. It even appears, he adds, that certain parts assume in all classes forms which have a relation to particular qualities of animals: for example, the anterior tubercula quadrigemina of the carp, which is the most feeble and least carnivorous of fishes, are proportionally larger than in the other genera, in the same manner as in the herbivorous quadrupeds.

The researches of Gall and Spurzheim, even though they may not have satisfactorily proved the details of phrenology, or ascertained the precise office of every portion of the brain, have certainly shown that the development of the cerebrum and the intellectual power invariably preserve a relation to each other. Müller remarks that one hemisphere is capable of performing the cerebral *functions* of both; and to illustrate this opinion, he quotes a case from Cruveilhier, in which, notwithstanding one hemisphere was so atrophied as to be only about half the dimensions of the other, the mind was perfect, but the opposite side of the body was paralysed. The commissures, he says, appear to be the cause of this unity of action of the two hemispheres. I must own, however, that Cruveilhier's case seems to me very far from conclusive; for the man had been paralysed from his youth, and it is therefore impossible to conjecture what might have been the power of his mind if the whole brain had been sound. It is true that he possessed memory, judgment, and all the other faculties in their ordinary state, just as the man who loses one eye is nevertheless able to see with the other; but is it not probable that they would have been more powerful, had no such lesion of the brain existed?

When paralysis, with disease of one of the hemispheres, attacks persons in the middle or toward the end of life, in a great majority of cases the intellect is weakened.

It might be supposed that the mental faculties are more especially dependent upon the cerebellum. From the experiments of Flourens and Rolando, it would, however, appear that volition, memory, and sensation, are not impaired by the destruction of this organ; though the animals which had undergone the operation, lost the power of controlling the muscular actions, and tumbled about like a drunken man. Rolando conceived that the cerebellum secretes the nervous principle, and Gall imagined it to be the organ of sexual desire. Much doubt, indeed, still exists respecting its office, though the experiments of Flourens and Rolando would lead to the supposition that it assists in regulating the muscular movements, and the observation of Magendie, that when the cerebellum is wounded the animal is impelled to walk backwards, confirms this view of its function.

The cerebrum, therefore, must be regarded as the seat of intellect, and consequently as the centre of the nerves of positive sensation.

The positive sensations are of two classes, namely, internal and external, all of which are usually produced by impressions upon the nerves, though irritation of the brain is likewise capable of exciting them. The same impressions, whether external or internal, excite in each nerve its peculiar sensations. Thus, congestion of the blood-vessels of the cerebrum, or of the optic, or of the auditory nerves, and a blow on the head, eye, or

ear, produce similar sensations of light in the one organ, and of sound in the other.

There are a few other circumstances which deserve our notice, before I conclude these general observations on positive sensation.

Impressions made upon the body or middle of a nerve of positive sensation, are usually referred to its extremity, which appears to be the most sensitive part. Thus, after amputation of a limb, the pain of the stump is often referred to the toes; or if a ligature be passed round the leg or arm, so as to deprive the extremity of feeling, the pain arising from pressure of the cord, gives a creeping sensation to the limb.

If, however, an injury to the body of a nerve be such as to disorganize the part, the sensation is felt in the portion of it which is thus injured. I do not know the reason of this phenomenon, but it is probable that the infliction of the injury may rupture some of the primitive fibres, so that their wounded ends receive the shock.

Sensations excited in one part are often manifested in another which is not really affected. Thus a decayed tooth frequently communicates pain to others which are quite sound. One explanation of this circumstance supposes that the impression passes from the extremity of the nerve in which it originated to its centre, and thence along another set of sensitive fibres to the part which is sympathetically affected. The other hypothesis attributes

the sympathetic affection to radiation of the irritation from the fibres, which were primarily affected upon the roots of other fibres. I should be rather inclined to adopt the first of these, unless we suppose that the nervous fibres anastomose with each other.

There is another curious fact respecting sensation, which has been very frequently noticed. In the talicotian operation, when a flap of skin is turned down so as to make a new nose, an impression made upon the nose is felt on the forehead. This is said to be the consequence of habit; and I am not acquainted with any better explanation. While indeed the root of the nerve remains in its natural situation, impressions on it enter the brain in the same manner as if the nerve had not been disturbed, and the altered position of the extreme fibres, would not be likely to make any difference in the sensations which they receive.

SECTION I.

OF THE INTERNAL POSITIVE SENSATIONS.

The internal positive sensations arise either from impressions on the brain itself, or from such as are transmitted to it by the posterior column of the spinal cord, by the larger portion of the tri-

facial, the glossopharyngeal, and the pneumogastric nerves.

They differ from the external sensations, of which I shall hereafter speak, both in their nature and in their effect, being less definite, less intense, and for the most part communicating less distinct ideas to the mind. The causes of this difference are, first, that the apparatus, which is attached to the internal nerves, is more simple and less fitted for discriminating the qualities of objects than that of the external senses; and secondly, that we have not the power of comparing together any two of these sensations, and thus correcting the inferences from them. For example, if a ball be grasped in the hand, every part of it comes in contact with the skin, whereby a clear idea of its shape is obtained; but if, on the contrary, it were to enter the intestinal canal, two sides of it only would touch the surface of the mucous membrane, which would give no impression of its globular figure. In the former instance, too, the sense of feeling would be aided by sight, while the internal sensation could derive no assistance from any such source.

Some of the internal sensations arise from the specific irritation of an organ by its own secretion; some from the excretions; and others from a disordered state of the viscera. Several of the internal organs, indeed, only excite sensation when in a diseased condition, and, even then, the uneasiness is rarely so acute as that which external parts are capable of affording.

This is well illustrated by the anxiety which so constantly accompanies lesions of the heart or large arteries; a feeling which, though quite as intolerable, is in no respect analogous to the pain which is produced by injuries of the skin and of the muscles of the limbs or trunk. The sensations which originate in disorders of the viscera are also themselves by no means an unusual source of disease; for thence arises the very frequent occurrence of hysteria, about the age of puberty, when the development of a new function affords a fresh species of excitement to the nervous system; and of a similar nature is the connexion between hypochondriasis and dyspepsia.

The purposes of the internal positive sensations are to excite those desires which promote the maintenance of the individual and the propagation of the species. Without the pangs of hunger and of thirst, we should probably neglect to search either for food or for drink; the frame would become emaciated, and we should perish without either knowing the cause of our malady, or receiving any intimation of the means whereby death might be averted. These sensations also give notice when the muscles are over exerted, when the alimentary canal is over loaded, when the excrements require expulsion, and when any of the internal organs are suffering either from disease or from accidental injury.

To the comparative obtuseness of the internal sensations may be in great measure attributed the

singular unconsciousness of danger in many of the disorders which affect vital organs; for, although nervous and painful diseases usually alarm the patient, the more fatal maladies, such as phthisis pulmonalis, commonly excite little apprehension in the mind of the sufferer, who is thus mercifully permitted to pass his last hours in peace.*

The internal, as well as the external, positive sensations exercise very great influence over the attitudes and motions of the body. Who, indeed, can have failed to observe the various expressions of countenance and contortions of the whole frame, which denote pleasure, pain, joy, grief, anger, or the other passions? What a difference is there between the expression of a person who is healthily digesting a meal, and that of the same individual when suffering from a fit of colic.

It is affirmed by Cabanis that the internal senses are developed before the external; and this is probably true, inasmuch as the latter are not perfected until some time after birth. Thus, many animals are born blind; and in none do the senses of seeing, hearing, and feeling immediately attain maturity. Upon the whole, I think it may be fairly assumed that the negative sensations come into action first, because upon them depend the movements of the vital organs, and consequently

* The debility which occurs in the nervous system in common with the other parts of the body during protracted illness, is another cause of the insensibility to danger in such cases.

life could neither begin nor go on without them; that next in order are the internal positive sensations, whereby the appetites are regulated; and that, lastly, the external positive sensations are superadded, to enable the living creature to communicate with the world at large.

Most of the internal positive sensations are evidently modifications of the sense of feeling; all those which are caused by pressure on the mucous membranes being simply instances of internal feeling; and it is a question whether all the positive sensations may not be considered as varieties of this sense. I shall not, however, speak of internal feeling separately, because it seems to me that the subject will be more clearly elucidated by explaining in detail the several species of this sensation than by accumulating them under one general denomination.

a. Of Hunger and Satiety.

The sensation of hunger performs a most important part in the animal economy, and is essential to the well-being of all creatures, from the zoophite to man: inasmuch as it periodically announces to the individual the necessity of supplying the waste which is constantly taking place in the body, and induces him to seek and take food. This sensation, however, is no doubt of a very different kind

in the lower and higher animals; for many of the former do not appear to be *positively* sensible.

Their simple nervous system, in which nothing that deserves to be called a brain is discoverable, can only be susceptible of negative sensations, and in them the act of taking food is as truly the effect of organic irritability as the closing of the Dionæa Muscipela upon the insect by which it is stimulated and on which it subsists. Thus in some of the radiata, which have no semblance of a cerebral system, the impressions arising from inanition are transmitted by the nerves to the mouths of the absorbents or of the stomach, which consequently open to receive the nutritious substances that float in the surrounding element; just as, in the human body, the lacteals imbibe chyle. In man, long abstinence from food creates what is termed "a gnawing at the stomach," which is succeeded by nausea and exhaustion; pains in the stomach, and the most violent craving for sustenance of any sort, no matter how disgusting it might have been under ordinary circumstances. Hunger is powerfully influenced by the mental emotions, and is allayed by sleep, by sedative medicines, and by pressure of the abdomen. The North American Indians place a board over the stomach and bind it tightly; by which means they are said to endure fasting for many hours and even days together, during their hunting expeditions.

Although this sensation is usually referred to the stomach, some physiologists have questioned the

fact. Mayo thinks it not impossible that a person might be hungry without a stomach. Müller speaks of the *local* and the *general* sensations of hunger; the former being those uneasy feelings which are experienced in the stomach, the latter, the debility and exhaustion which succeed them. He attributes these sensations to the absence of food in the stomach; and says that the aliment being an adequate or homogeneous stimulus to the digestive organs is made known to the sensorium by the nerves. According to Dr. Fletcher, however, hunger arises from a kind of permanent though partial contraction of the muscular fibres of the stomach; not that alternate general contraction and relaxation which produce a sensible motion of the organ, nor that permanent general contraction which would serve to diminish its cavity, but that kind of permanent contraction which takes place in certain fibres alone, and perhaps through a part of their length only, and by which these fibres are, as it were, drawn away from the others; or in other words, a minor degree of cramp. Friction of the coats of the stomach against each other, and the stimulant action of the saliva, the bile, and the gastric juice have also been assigned as causes of hunger.*

Absence of food in the stomach is manifestly one cause of hunger; but the sensation appears to be influenced by the irritation of the gastric juices, which

* Magendie has opened the stomachs of animals suffering from hunger, but never found the coats in contact.

must act more powerfully upon the coats of the stomach when empty than at other times. There are indeed many other stimulants which are well known to produce appetite, and it has been long the practice to administer them for that purpose. A draught of cold water, a glass of wine, pepper, mustard, and the vegetable tonics have a tendency to create hunger, and can only do so by their stimulant properties. I should, therefore, imagine hunger to be the effect of the removal of the stimulus of food, and the substitution of that of the secretions in the alimentary canal; and the experiments of Brachet tend to show that these impressions are conveyed to the brain by the pneumogastric nerves. The conclusions of Brachet are not, however, supported by comparative anatomy; for, according to Sir C. Bell, the pneumogastric nerves "do not exist but where there are a heart and lungs to associate with a muscular apparatus of respiration;" whence it would seem likely that the gastric branches of this nerve do not perform any function which is peculiar to the stomach, but assist in harmonizing or combining the movements of the digestive and respiratory organs. It has, moreover, been observed that animals eat, even voraciously, after these nerves have been divided; though this has been attributed to loss of sensation in the stomach, and the consequent unconsciousness when it is full, and it must be remembered that the pneumogastric is a sensiferous nerve; so that it is still a question whether the impressions that excite hunger be conveyed to the

brain by this, or by some of the cerebral nerves, which join the ganglionic system. Müller makes a distinction between hunger and appetite; but this is surely an unnecessary refinement, for both denote the desire for food, and differ only in degree, not in kind.

The general exhaustion which accompanies this as well as several other internal sensations is a sympathetic affection, probably dependent upon the impressions which the cerebral fibres of the sympathetic nerve communicate to the whole nervous system.

The sensation of SATIETY which occurs when the stomach is full has its seat in the same organs as hunger, but is the result of a very different cause, being produced by distension of the stomach.

β. *Of Thirst.*

The desire for drink, which is called thirst, is caused by dryness or heat of the mucous membrane of the alimentary canal. It is brought on by inflammation, fever, warm weather, or exercise; by fear, and other mental emotions; or by any other circumstance which increases either the velocity of the circulation, or the cutaneous exhalation; and by morbid secretions of the stomach.

The impression is carried from the fauces and stomach to the brain by the numerous cerebral filaments which are distributed over the internal

membrane of these parts; but I am not acquainted with any experiments by which we can precisely determine what particular nerves belong to this sense.

γ. *Of Digestion and Indigestion.*

Digestion is a pleasurable sensation, which excites no irritability, but rather tranquillizes the nervous system, and spreads a genial warmth over the whole body.

The sensations accompanying Indigestion are produced either by the irritation of insoluble food, or by the morbid secretions of the stomach, which may be either the cause or the effect of disorder. They consist of local pain either in the stomach itself, or sympathetically in some other organ, as from palpitation of the heart; or of general uneasiness. Since the stomach is the seat of the impressions which arise from healthy digestion as well as from indigestion, both sensations must be referred either to the pneumogastric nerve, or to some of the cerebral filaments which accompany the branches of the sympathetic nerve.

δ. *Of the Sexual Sensations.*

The sexual sensations of the male arise partly from accumulation of blood in the genital organs, the arteries and veins of which are very peculiarly

arranged, and partly from the semen in the seminiferous vessels. The first of these stimuli is, however, alone capable of producing these sensations; for eunuchs, in whom the penis is fully developed are very salacious; although both men and animals, who have been castrated before the age of puberty, are entirely destitute of venereal propensities.

In the female, the sexual sensations are caused by accumulation of blood in the genital organs, as in the male, and by irritation of the ovaries. These conditions of the parts and the consequent sensations may be excited either by the cerebral influence, or by irritation of any portion of the genital organs, more especially the penis in the male, and the clitoris in the female, the erectile tissue of which renders their nerves highly susceptible of impressions. In women, the sexual desire is also produced by friction of the nipple; and they experience a somewhat similar, though much less intense, sensation in suckling their children.

The sexual appetites exercise great power over the imagination, and are themselves always controlled, as well as sometimes created by mental emotions. When the desire proceeds from excitement, either of the genital organs or of the mammæ, the impression is conveyed along the cerebral filaments which join the ganglionic nerves, and thence by the posterior column of the spinal cord to the brain; but if the stimulus originate in the cerebrum it of course pursues the contrary direction.

The influence of external objects upon the sexual

propensities is one of the most remarkable phenomena appertaining to this subject. It is the result of the connexion, which the brain establishes between the external and the internal sensiferous nerves, and of the mental faculty, called association, whereby ideas are so grouped, or linked together in certain sets, that if one arise it calls forth the others, which may happen to have been united with it in the mind.* Thus, the sight of a beautiful person awakes desire; and if from frequent intercourse the feeling be maintained, the individual and the passion become so associated together, that when the one occurs to the mind, it inevitably suggests the other. In like manner, the sexual desires of the dog and other quadrupeds appear to be aroused by impressions on the olfactory nerve.

Owing to the association of ideas, these passions, if once allowed to gain an ascendancy in the imagination, ultimately occupy every thought, to the infinite detriment of the mental powers. Nevertheless, when kept in ordinary subjection, they not only give to the bodily functions that wholesome stimulus which is manifested at puberty and continues until the beginning of decay, but, moreover, as Hartley has remarked, there is great reason to apprehend that if this source of the benevolent affections were destroyed, mankind would become much more selfish and malicious, much more wicked and miserable, than in the present state.

* On this subject see Hartley.

ε. *Of the Sensations which arise from the Accumulation of Excrements.*

The sensations which arise from an accumulation of fæces in the intestinal canal, and those from urine in the bladder, are caused by the pressure and irritation of the cerebral filaments, which join the ganglionic nerves. They are the result of a mechanical stimulus, and subside as soon as the excrements are expelled.

The sensations which originate from flatulency are of a precisely similar nature.

ζ. *Of Nausea.*

Nausea appears to be dependent on the pneumogastric nerves; since irritation, either of their œsophageal or of their pharyngeal branches, creates this sensation as much as irritation of the stomach itself; and when their trunks are divided, poisonous substances introduced into the stomach do not produce the ordinary effects. It is, however, very often symptomatic of disorder in other parts of the body, such as calculus in the kidney or the bladder, wounds of the head, the slight concussion of the brain which is occasioned by the motion of a swing or of a vessel at sea, and the disturbance of the uterus during pregnancy.

In these instances, nausea is a sympathetic affec-

tion, induced by irritation of the brain itself, or of some nerve which is either a branch of the pneumogastric, or communicates with it through the medium of the spinal cord. Hence also emetics injected into the veins, and bathing the head with a strong infusion of tobacco, excite nausea; though by far the most common cause is the presence of indigestible or acrid substances in the stomach.

η. *Of the Respiratory Sensations, of certain Morbid Sensations, and of those which accompany Deglutition.*

I have now to mention several internal sensations of which we are scarcely conscious during health, though they are very commonly symptomatic of disease.

1. The desire to breathe, and the painful sensations which accompany difficult respiration, are caused by the impression of the air upon the cerebral filaments which join the ganglionic system.

This is evident from the fact, that by dividing the pneumogastric nerve, which is the only other channel through which the impression could be transmitted to the brain, although the respiratory movements are paralysed, and negative sensation ceases, the uneasiness is as great as in common asphyxia, and respiration is for a time supported by a voluntary effort; whereas positive sensation would have been instantly annihilated, if its organ had been cut off from the brain.

2. The sensations arising from palpitation of the heart have their seat also in these nerves, as the experiments of Brachet and others prove.

3. I have already stated, as a law, that sensations are modified by the condition of the other functions, and this is nowhere better exemplified than in the internal organs; for the viscera and their membranes, which in health are scarcely sensible, when suffering from inflammation or other diseases, become most acutely sensitive. We constantly witness this morbid sensitiveness in cancer of the stomach and peritonitis, in which the nerve of the affected organ is preternaturally stimulated.

4. The sensations accompanying deglutition are caused by the pressure of food upon the fibres of the glossopharyngeal and pneumogastric nerves, which are distributed over the mucous membrane of the pharynx.

θ. *Of Vertigo.*

Vertigo or giddiness is dependent on a disturbed state of the neurine of the brain, and may be caused by turning round rapidly several times in succession; by the rolling of a ship at sea; by swinging; by looking down from a great height; or by turning any object quickly before the eyes. The mental emotions are also capable of producing vertigo, independently of these sensations. As it is in some instances the effect of irritating impressions upon

the nerves of a single sense, it may often be prevented by steadily fixing the attention on one object. Many persons are enabled to avoid it at sea, by looking constantly at the mast of the vessel; but in others, who are more subject to sickness, and in whom the motion of the ship appears to produce slight concussion of the brain itself, no effort will avert giddiness. While Dr. Darwin was passing in an open boat from Leith to Kinghorn, in Scotland, a sudden change of wind shook the undistended sail, and stopped the boat; from this unusual movement the passengers all vomited except himself. He observed that the undulation of the ship, and the instability of all visible objects, inclined him strongly to be sick, and this continued or increased when he closed his eyes, but as often as he bent his attention with energy on the management and mechanism of the ropes and sails, the sickness ceased; and recurred as often as he relaxed this attention. Excessive drinking of spirits is another very common cause of vertigo.

1. *Of the Muscular Sense.*

Another set of internal sensations is excited by the contraction of the muscular fibres. "If we have to raise a weight," says Mr. Mayo, "this sense enables us to exert the force which is exactly necessary. Supposing again, that we have raised and are supporting a weight by the hand,

the effort, which seems a continuous one, is in fact a succession of efforts; and each, like the first, is measured by the weight we are sensible of. The same sense keeps us alive to the necessity of continuing the exertion."

This is a most important sense, without which the voluntary movements could not be performed with precision or steadiness; neither could we regulate the power exerted, nor proportion the effort to the effect which might be required. It is one of the principal controllers of the velocity, direction, and energy of the voluntary motions; and, as Dr. Bostock has remarked, the skill which certain individuals acquire in the mechanical part of music, as well as the great dexterity of rope-dancers, tumblers, and jugglers, depend in great measure upon their accurate perceptions of the contraction of muscles, a faculty which, in this as in all other analogous instances, is to be referred partly to an original delicacy in the nerves of the part, and partly to custom and education. It is the want of the muscular sense which gives the peculiar gait to those in whom sensation of the lower extremities is partially paralysed; and I am inclined to think that, in many cases of chorea, the twisting of the limbs may be referred to this cause. Our appreciation of weight appears to be dependent upon the degree of pressure which the muscles in contracting exercise on the nerves.

κ. *Of the Sensations of Consciousness.*

The last internal sensations of which I have to speak are the sensations of consciousness. They are those which arise from the mind's being conscious of its own actions, or, in other words, they are those whence we derive the knowledge that we are *thinking*, and that the brain itself, on which they depend, is in operation. It is thus that we become conscious of abstract ideas, all of which are the result of mental action.

SECTION II.

OF THE EXTERNAL POSITIVE SENSATIONS.

By numerous experiments it has been proved that the external sensations are dependent on the cerebral nerves. In some respects there is a material difference between the external and the internal sensations: the former, which are produced by the objects around us, being more distinct, and presenting greater variety of character than the latter, which are merely the result of the development, functions, or disorders of the organs.

From the latter we derive the consciousness of our own existence, from the former a knowledge of the other works of nature and of art. Everything

around us is capable of acting upon our senses, and of producing some kind of impression. The nerves, however, possess various degrees of sensibility, for the optic nerve can alone transmit the impressions of light; the auditory nerve those of sound, &c. &c., just as one set of capillary vessels is adapted to receive lymph, and another bile. They are excited, indeed, by almost every kind of stimulus; but the sensation peculiar to each nerve is the only effect produced. The external sensations may be divided into five classes, namely, feeling, tasting, smelling, hearing, and seeing; each of which performs the function that is denoted by its name.

These sensations may be caused either by single objects or by the combination of several, in such a manner as to give one impression. Thus, the ear receives at once the sound of a single instrument, or the combined sound of many, when they harmonize together so as to create music; and the eye contemplates the various shades of a landscape without exciting any mental analysis of the colours of which it is composed.

In addition to their peculiar offices, the external sensations also assist and modify each other; so that, as Cullen has remarked, impressions are often rendered objects of desire or aversion by their combination, succession, and relation. The smell and taste especially exercise a mutual influence, for though their functions are distinct, and what pleases the one does not always please the other, yet substances which are disagreeable to the taste usually

become so to the smell, and vice versâ. Nor are these mutual offices limited to the external sensations; for the internal positive sensations, being connected with the brain by means of the nerves, modify, and are modified by them. Thus the taste or smell of a savoury dish excites hunger; while the sight or smell of putrid flesh, or of any other disgusting object, has a tendency to destroy the appetite. These are examples of the action of external agents on internal sensations; and the internal impressions in like manner affect the external sensations; for it is well known that an attack of indigestion disorders both the taste and the sight, and other instances might, if it were necessary, be adduced.

The acuteness of the external senses is increased by education or exercise. By instruction in music, for example, the ear may be taught to detect the variations of sound with an accuracy which it does not naturally possess, and the greatest perfection of this faculty is acquired by the savage tribes, whose safety in a great measure depends upon the perception of distant sounds.

The power which the epicure attains of discriminating between various wines and dishes, which to common palates seem precisely similar, is also another proof that exercise augments the susceptibility of the sensitive organs.

If, however, the same impression be very frequently repeated at short intervals of time, it soon ceases to affect the external senses so vividly as at

first; and it may return so often as ultimately to become imperceptible.

Dr. Roget has remarked that when impressions are very vivid, they recur after a certain interval. If for instance we look at the sun for a second or two, and then close the eyes, the image of it remains for some time before us, as if the retina were still acted upon by its light; it then disappears, and afterwards again returns. This will be repeated several times, the sensation becoming fainter at each renewal. Dr. Roget thinks that the reappearances of the image are occasioned by spontaneous affections of the retina itself, which are conveyed to the sensorium, but it seems to me quite as probable that they are the effect either of memory or of imagination.

Numerous observations have further shown that the loss of any one of the senses tends to increase the acuteness of the rest. Hence the blind commonly possess the sense of feeling in a very extraordinary degree; while, in the deaf and dumb, the sight is usually very acute; for since the acuteness of the senses is increased by education, if one of them be destroyed, the rest being called into greater activity must be thereby invigorated.

Without exercise, the external senses, none of which are perfectly developed at birth, could never arrive at maturity; for we find that very young children are not able accurately to distinguish the differences between shades of colour, or to measure space either by the eye or by the ear, until they have for some time been accustomed to use them.

I once saw a child who, having been born blind, had undergone the operation of couching, from which it had just recovered. It had evidently no idea of distance, for it frequently ran against the wall, and at other times drew back from objects which were several yards distant.

Upon the development of the senses, chiefly depend the tastes and dispositions of individuals of the human race, as well as of other animals, which vary according to the proportional energy of the sensitive organs, and are for the most part regulated by the predominancy of particular sensations. The impressions of external things are transmitted by the nerves to the brain, and from these sensations, as Mr. Locke has shown, all our knowledge of the surrounding world is derived.* Sensation is indeed the primary source of all our ideas. "He," says Locke, "that attentively considers the state of a child, at his first coming into the world, will have little reason to think him stored with plenty of ideas, that are to be the matter of his future knowledge; 'tis by degrees he comes to be furnished with them. And though the ideas of

* Mr. Locke first *proved* that *all* knowledge is primarily obtained by sensation; but the fact seems to have been known both to the author of the works which are attributed to Hippocrates, and to Aristotle.

In the Παραγγελιαι of Hippocrates it is clearly asserted that sensation is the conductor of impressions to the sensorium; that objects are first subjected to the senses, and afterwards collected by the reasoning faculty, and that when they have been repeatedly presented to the mind, it retains them by means of the memory. That Aristotle held similar doctrines may be inferred from numerous passages both in the Περι Ψυχης, and in the Περι Αισθησεως.

obvious and familiar qualities, imprint themselves before the memory begins to keep a register of time and order; yet 'tis often so late before some unusual qualities come in the way, that there are few men that cannot recollect the beginning of their acquaintance with them: and if it were worth while, no doubt a child might be so ordered, as to have but a very few even of the ordinary ideas, till he were grown up to be a man. But all that are born into the world being surrounded with bodies that perpetually and diversely affect them, variety of ideas, whether care be taken about it or no, are imprinted on the minds of children. Light and colours are busy at hand everywhere when the eye is but open. Sounds, and some other tangible qualities, fail not to solicit their proper senses, and force an entrance to the mind; but yet I think it will be granted easily, that if a child were kept in a place where he never saw any other but black and white till he were a man, he would have no more ideas of scarlet or green, than he that from his childhood never tasted an oyster or a pineapple, has of those particular relishes."*

The philosophical views of Mr. Locke, with regard to the influence of the sensations on the mind, and the sound arguments by which they are supported, must I think convince every one who is capable of understanding the subject, and espe-

* Essay on the Human Understanding. This is beautifully illustrated by Condillac's imaginary statue; concerning which, see his *Traité des Sensations.*

cially those who, having studied physiology, are enabled to appreciate the support which that science affords to his opinions.

By pursuing the same principles, Cabanis has also proved that, while our knowledge of external things is derived from the external sensations, it is by means of the internal sensations that we are made acquainted with the conditions of our own bodies, as I have stated in another place. I am, however, aware that there are still some persons who believe in the doctrine of innate principles; and I shall therefore, by way of illustration, quote a passage from the "Observations made by a young gentleman who was born blind, or lost his sight so early that he had no remembrance of ever having seen, and who was couched between thirteen and fourteen years of age." The case was reported by Mr. Chesselden, in the Philosophical Transactions.

"When he first saw, he was so far from making any judgment about distances, that he thought all objects whatever touched his eyes, as he expressed it, as what he felt did his skin; and thought no objects so agreeable as those which were smooth and regular, though he could form no judgment of their shape, or guess what it was in any object that was pleasing to him. He knew not the shape of anything, nor any one thing from another, however different in shape or magnitude; but on being told what things were, whose shape he before knew from feeling, he would carefully observe, that he might know them again; but having too

many objects to learn at once, he forgot many of them; and, as he said, at first he learned to know and again forgot a thousand things in a day. One particular only, though it may appear trifling, Mr. Chesselden relates: Having often forgot which was the cat and which the dog, he was ashamed to ask, but catching the cat which he knew by feeling, he was observed to look at her stedfastly, and then setting her down, said 'so, puss! I shall know you another time.' He was very much surprised that those things which he had liked best did not appear most agreeable to his eyes, expecting those persons would appear most beautiful that he loved most, and such things to be most agreeable to his sight as were so to his taste. They thought that he soon knew what pictures represented which were shown to him, but they found afterwards they were mistaken; for it was not until about two months after he was couched, that he suddenly discovered they represented solid bodies; till that time having considered them as particoloured planes or surfaces diversified with variety of paint. But even then he expected that the pictures would feel like the things they represented, and was amazed when he found that those parts which by their light and shadow appeared round and uneven felt only flat like the rest; and he asked which was the lying sense, feeling or seeing."

This case is an excellent illustration of Locke's doctrines; for the ideas of colour were certainly not innate in this boy, nor did he acquire clear

conceptions respecting this quality of objects until his eyes had had considerable practice.

But, although without the external sensations we should know nothing, they sometimes misguide us, and lead the mind to form erroneous judgments by presenting to it illusive impressions. Dr. Roget, who seems to have paid much attention to this subject, and who has treated of it in his Gulstonian Lectures, as well as in his Bridgewater Treatise, remarks that these illusions are the direct consequences of the very same laws, which in ordinary circumstances direct our judgment correctly, but are then acting under unusual or irregular combinations of circumstances; and that they may be arranged under three classes, according as they are dependent on causes of a physical, physiological, or mental kind. The first class includes those illusions which are the result of impressions to which we are unaccustomed, such as the deceptions arising from echoes, ventriloquism, the phantasmagoria,* &c. The second class includes those which are caused by a peculiar state of the nerves, which receive the impressions; whence arise singing in the ears, various ocular spectra, and certain depraved tastes. The third class of illusions comprehends those which are the consequence of derangement of those reasoning powers, whereof the brain is the seat. It is unnecessary to mention examples of these fallacies, as they are to be found in almost every book on insanity; and

* See Sir D. Brewster's Animal Magic, for examples.

many very curious anecdotes on this subject are related in Sir W. Scott's Letters on Demonology. We have now done with the laws of sensation, but it still remains for us to consider the external senses individually. This I shall do as briefly as possible; for though it is my object to mention all the facts which involve or elucidate the general phenomena of sensation, yet I shall as far as possible avoid entering into minute anatomical details.

a. Of Feeling.

The sense of feeling is exercised by the internal as well as the external parts; but as I have already spoken of the sensations of the former, it is unnecessary again to notice them, and my observations in this place will therefore have reference only to impressions on the outer surface of the body.

By this sense we are enabled to ascertain the shape, hardness, softness, roughness, smoothness, extension, motion, and temperature of bodies that come in contact either with the skin or with some of the membranes; certain portions of which, however, possess much more sensibility to tangible objects than others. Hence arises the distinction between tact and touch, which are the terms used to denote the two degrees or species of feeling.

"Tact," says Magendie, "is, with some few exceptions, generally diffused through all our organs, and particularly over the cutaneous and mucous surfaces,—it exists in all animals; while touch is

only exerted by those parts which are specially intended for this purpose. Touch does not exist in all animals; and it is nothing else but tact united to muscular contractions directed by the will. In the exercise of tact we may be considered as passive, whilst we are essentially active in the sense of touch."*

In man, the hand is the principal organ of touch; and its agent is the skin.

The skin consists of three portions, namely, the cuticle or epidermis, the rete mucosum, and the cutis vera or chorion; of which, the first is the external and the last the internal layer, the rete mucosum lying between the other two. The cuticle is a delicate transparent membrane, which is thickest in the palms of the hands and soles of the feet. It is perforated in a vast number of places for the passage of hairs and of the cutaneous perspiration. During life it possesses no sensibility, and after death it is not subject to putrefaction. The rete mucosum was supposed by Malpighi to be composed of a peculiar mucus, having the form of fibres, which cross each other in various directions; and some physiologists consider it as a vascular network. Cloquet says, "that it consists of four distinct layers: 1st, a vascular tissue; 2d, a white tissue; 3d, an assemblage of small granulations; 4th, another white tissue." The cutis vera is a fibrous texture, formed by cellular tissue, arteries,

* Magendie's Physiology.

veins, and nerves, interwoven with each other. On its external surface there are numerous small reddish projections, called papillæ, which are disposed in pairs, and are most prominent on the sole of the foot and the palm of the hand. They are highly vascular and sensitive; and there is opposite to the top of each a small hole in the cuticle, through which the perspiration may be seen to drop. The skin contains a great number of sebaceous follicles, and is well supplied with nerves, more especially in those parts which exercise the sense of touch. The sense of touch is practised by the tongue as well as by the hands, but in a minor degree.

It was formerly supposed that the same nerves were both sensiferous and motory; but the discoveries of Sir C. Bell have proved the erroneousness of this opinion, and shown that a distinct set of nerves is allotted to each of these purposes. From the experiments of this great physiologist, as well as from those of Magendie and Mayo, it would appear that the nerves of the sense of feeling (in external parts) are those which arise from the posterior column of the spinal cord, and those fasciculi of the trifacial which pass through the gasserian ganglion.

Professor Blumenbach asserts that the nerves of feeling terminate in the papillæ of the cutis vera, which he therefore regards as the immediate seat of this sense; and Breschet corroborates his statement; but Magendie says, that "the mode in which nerves terminate in the skin is totally unknown; and that all which has been said of the cutaneous

nervous papillæ is hypothetical. The sense of feeling is most acute when the chorion is thin, and the temperature of the body rather above than below its usual standard; hence our sensibility to tangible objects varies according to the condition of the part to which they may be applied, as well as according to the general state of the constitution."

The impressions of heat, cold, dryness, moisture, and those which arise from friction, pressure, or mechanical injury, are perceptible in every part of the skin, and produce sensations of tact. There are, however, many circumstances which may render our estimate of these impressions exceedingly fallacious. This is particularly remarkable with regard to temperature, for our feelings of heat and cold are entirely relative, being dependent upon the capacity for caloric of the substance with which we come in contact, and upon its warmth compared with the atmosphere and with our own bodies. Thus, a piece of metal which is hotter than the atmosphere communicates to us the sensation of heat, even though it be colder than ourselves.

Under all these circumstances the difference of temperature produces a specific irritation in the nerves, by which the impression is conveyed to the brain. Dr. Bostock thinks it probable that the impressions of temperature and those of touch, are received by different nerves, because we find that the sensibility to resistance and to temperature are not proportioned to each other; and because this difference has been observed in certain morbid con-

ditions of the body: but to me this theory appears inadmissible; for every nerve which is susceptible of pain from the application of heat is so likewise from pinching, pricking, or cutting. The sensations of heat are, like other sensations, influenced and modified by the affections of the mind, as well as by disorders of the body.

Dr. Elliotson mentions a curious remark of Weber's, that if the skin of a person whose eyes are shut be touched with two points of a compass which are an inch asunder, he is conscious of the two impressions; but that if the points be gradually moved closer together, he at length feels as if he were touched by one body only. Weber also lays it down as a law, "that the distance between any two bodies which may be applied to the skin appears to be the greatest in those parts of it which are most sensitive;" and he also found that the apparent space between two bodies which are placed on different surfaces, as, for instance, upon the two lips, is greater than when they are both upon the same.

These discrepancies prove that tact cannot always be relied on, and might be supposed to render it of little utility; but, since the great purpose of this more feeble species of feeling is to protect the body from external injury by warning us of it, we must allow that these sensations are sufficiently accurate to accomplish their intended object.

Those parts which are endowed with the sense of touch are amply provided with nerves, have a

fine thin cuticle, a large number of papillæ, and such mobility that they can closely grasp bodies of every shape. All these requisites are possessed by the human hand in the greatest possible perfection, and render its touch surpassingly delicate; while in animals which have not this organ, the lips, the tongue, the nose, or some other parts which are flexible, and in other respects qualified for the office, perform that function. The giraffe, for example, whose tongue is very long and slender, wraps it round the leaf of the tree on which it is about to feed, and so draws it into the mouth. In this animal, the tongue is manifestly the principal organ of touch, as the trunk is in the elephant, and the feelers or tentacula are in some of the lowest tribes of animals.

Touch, being the means whereby a great part of our knowledge of the material world is acquired, has been commonly esteemed to be the most accurate and important of the senses, but there is no foundation for this supposition; it is in fact, like the others, liable to illusion. This is illustrated by the experiment of crossing the fingers, and then putting a pea between them, when the single pea thus placed gives the impression of two distinct bodies.

To ascertain the tangible qualities of any substance, the hand must either be drawn along its surface, by which the shape, roughness, or smoothness becomes perceptible; or it must be pressed against it, for the purpose of discovering its con-

sistency. Our ideas of figure, shape, space, extension, and motion are not, however, entirely dependent upon touch, but may also be derived from sight. Thus, we judge of the extent of a landscape, of the height of a mountain, and of the size of the figures in a picture by sight alone; whereas if a person be confined in a dark room, the notions of extension which arise in his mind can of course only be obtained by feeling or by hearing. In like manner our ideas of figure, which arise from comparing the relative proportion of the component parts of a body, and our ideas of place or of the position of a body with relation to certain fixed points, are founded either upon measurement with the hand or with the eye; or if it be a sounding body, by the ear.

Our ideas of roughness and smoothness, which in fact are included in those of figure, are also acquired by sight as well as by touch; but the hardness, softness, and elasticity of bodies are perceptible by the sense of touch only. The idea of hardness is produced by the resistance which certain substances offer to those parts of the body which exercise this sense, when pressed against them; nor can it be communicated to the mind by any other channel. To the eye a smooth sheet of water appears to be as hard as a piece of glass; and the tongue only recognizes the difference between hardness and softness, because it is an organ of touch; for I need not say that taste could afford no assistance in such a case, inasmuch as

the same flavour may be, and very frequently is, given by the art of cookery to every description of food, in whatever form it may be brought to table. Hardness and softness are, however, relative terms: the former being that quality of bodies whereby they are enabled to preserve their figure when touched, and the latter denoting the absence of this property. In much the same manner we acquire ideas of impenetrability, or that attribute of bodies which enables them to resist external pressure be it ever so powerful. "All the bodies in the world," says Mr. Locke, "pressing a drop of water on all sides, will never be able to overcome the resistance which it makes to their approaching one another, till it be removed out of the way."

The sense of feeling is of the utmost importance in directing the locomotive organs; for without it we should walk indifferently over rough or smooth, hot or wet places; we should stumble at every step, and the foot would soon be maimed and useless.

β. *Of Tasting.*

The sense of tasting resides in the tongue and internal parts of the mouth, so that every kind of food which enters the stomach must be previously subjected to its ordeal. Thus, we are in a great measure enabled to judge of its fitness for digestion, since those substances which are nutritious, for the

most part, have an agreeable flavour, while those which are injurious commonly excite disgust. The utility of this sense is not, however, so conspicuous in man as in other animals, most of which recoil with instinctive fear from plants which are poisonous, or from any food which may be unsuited to their digestive powers. It is highly probable indeed, that if deprived of this sense and of that of smelling, by which it is assisted in its office, the brute creation when suffering from hunger, would indiscriminately devour whatever might first come in their way, whether herb or flesh, instead of selecting that which is nutritious; for we find that maniacs and persons in whom the taste has been vitiated by disease display the inclination to eat the most impure substances.

The tip, the edges, and upper surface of the tongue are more sensible of the impressions of taste than any other parts. They are enveloped in mucous membrane, which is rendered very uneven by numerous papillæ, of which there are three sorts: 1st, The lenticular papillæ, which are situated toward the base of the tongue, and are arranged in two oblique lines, so as to form two sides of a triangle; 2dly, the fungiform papillæ, which are scattered about the edges of the tongue; and 3dly, the conical papillæ, which occupy the space that is bounded by the lenticular papillæ, the edges and the apex of the tongue. According to Cloquet, they are produced by the expansion of the filaments of the lingual nerve, and are enveloped by a vascular

network; but Magendie has in vain endeavoured to trace the nerves into the papillæ.

With regard to the nerve of taste, there is as yet considerable difference of opinion among physiologists. Bell, Mayo, and Müller agree in assigning this office to the lingual branch of the trigeminus nerve; and in confirmation of his views Müller remarks, that loss of taste has been observed in cases where this nerve had suffered from disease; that Magendie noticed the same effect after dividing it; and that the experiments of Mayo, Gurlt, Kornfeld, and himself, were attended with a similar result. The investigations of Panizza have, however, induced him to suppose that the lingual branch of the trigeminus is a nerve of feeling only, and that the glossopharyngeal is the real nerve of taste; for animals in which the latter had been divided swallowed colocynth and other nauseous substances with as much eagerness as their ordinary food. On the other hand, Müller asserts that the sense of taste remains quite perceptibly after division of the glossopharyngeal nerve; but he very justly adds, that experiments of this kind are attended with difficulty, and are liable error. Upon the whole I am inclined to think that the lingual nerve is the nerve of taste, because that is the inference which would be drawn from pathological observations, which are far more to be relied on than experiments upon living animals; at the same time it must be acknowledged that there is still much doubt upon this subject.

For the perfect exercise of taste it is necessary that the tongue, its membrane, and the nerve of special sensation be in a sound state; and that the mouth be lubricated with mucus and saliva. To acquire the full flavour of food, it should be pressed against the palate, so that every particle may be in close contact with the tongue, and it must remain some time in the mouth, that the solid parts may be dissolved; for it would appear that nothing can be tasted unless it be reduced to a fluid.

The taste for various kinds of food undergoes considerable alterations during the progress of life; for this sense, which during childhood is gratified by sweet and bland substances, after the frequent repetition of such impressions at length becomes callous to them, so that in old age we usually prefer a more stimulant and pungent diet.

So agreeable are many of these sensations, and so great is the influence of taste upon the mind, that the glutton will sacrifice every moral feeling to their gratification.* When, however, the taste is rationally indulged, it seems to have a beneficial influence on the mind by contributing to happiness, and thus calling forth those better dispositions of our nature which fit man for a social existence.

Taste is closely associated with smell, and more

* A curious instance of this is related by Dr. Percival respecting Theophilus Cibber, who, he says, "was known to purchase an ortolan with the guinea he begged as charity; and to give for a dish of green peas a much larger sum, with which he was intrusted for the relief of a friend in distress."

remotely with sight; so that those aliments which are pleasing or offensive to either of the two latter senses, are very liable to excite corresponding impressions on the former. Hence the flesh of animals which we are unaccustomed to eat almost always produces disgust, even though the taste be really unobjectionable.

γ. *Of Smelling.*

1. Of Odours.

Odours consist of small particles of a peculiar nature, which are detached from almost all substances; without, however, perceptibly diminishing their weight. They float in the air, and are by its agency carried to the olfactory organs, where they excite the sensation of smell.

2. Of the Organ of Smelling.

The apparatus of this sense is composed of the pituitary or Schneiderian membrane which lines the cavities of the nose; of the maxillary, frontal, and spheroidal sinuses, and the ethmoidal cells; and of the olfactory nerves, whose branches pass through the ethmoidal cells and terminate in the membrane of the nose. The Schneiderian membrane is very soft, highly vascular, and secretes mucus, by which it is constantly lubricated.

3. Of the Physiology of Smelling.

To the mucous surfaces the odoriferous particles adhere, and are thus applied to the sentient extremities of the olfactory nerves, by which their impression is conveyed to the brain. The odour of external bodies is drawn into the nose with the air, which is inhaled in inspiration; and if we hold the breath, even powerful scents do not affect us; but the smell of substances in the mouth is only perceptible during expiration. In both cases, the air is merely the vehicle of the odoriferous particles, and does not otherwise affect the sensation than by carrying these substances in its current. Magendie seems to think it may be possible that the olfactory nerve is not the nerve of smell; for after having destroyed it in a dog, the animal seemed to perceive *strong* odours when presented to it, and conducted itself as it would probably have done in the ordinary state. Weak odours, however, produced no effect whatever; so that we may probably attribute the influence of the strong smelling substances to the irritation that their pungency would cause in the trifacial nerve, which is the organ of general sensibility of this part, and not to their specific action as odoriferous bodies.

The sinuses afford a large surface for the secretion of mucus; but whether they perform any other office connected with the sense of smell is not known. The olfactory organs are placed at the entrance of the air-passages, to give notice of the

approach of gaseous or other bodies, which may be unfitted for respiration. To render the apparatus more effective, the lining membrane of the nose is highly sensible to impressions of feeling as well as of smell; so that we detect the small particles of dust or other solid matters which possess no perceptible odour with the same degree of certainty as we do chlorine or sulphuretted hydrogen gas. The smell is also a powerful ally of the sense of taste, which it assists in discriminating the nature of various substances, and in selecting those which are best suited for food; so that, while the appetite is stimulated by the odour of most nutritious substances, the smell of those which are innutritious or unwholesome usually creates loathing. Such at least is the case when the senses have not been vitiated by luxury. Indeed, the taste cannot be perfectly exercised without the sense of smelling; for if the nostrils be closed, meats even of strong flavour become comparatively insipid. In the less civilized races of mankind, and in many animals, especially those which are carnivorous, the organ of smell is more fully developed than in Europeans; and this sense answers other purposes in addition to those which I have mentioned. The savage tribes have doubtless more frequent occasion to exert this faculty than those who, by a more extensive education, have acquired other sources of knowledge; while in the dog smell appears to constitute the principle guide by which it finds its way from one place to another, and traces the footsteps of its prey,

and of the master by whom it is fed. In like manner the newly-born child is attracted to the breast of its mother by the smell of her milk long before the sight and hearing are sufficiently perfect to direct its motions.

In brutes the sense of smelling has great influence both over the passions and over the internal sensations. Thus, in the dog the smell of urine produces the desire to void it; and in all quadrupeds the odour which arises from the genital organs of the female at certain periods excites the sexual propensities of the male.

Smelling, like the other external senses, may be considerably strengthened by the habitual exercise of it, and by a careful attention to its indications; a most striking example of which is afforded by Mr. Wardrop's account of James Mitchel. This boy, who was born deaf and blind, seemed to form his opinion of every person about him by the smell; for when any stranger approached him, he would lay hold of the arm or some other part of the body, put it to his nose, and after having taken two or three deep inspirations, he would show a disposition either to become better acquainted with the individual, or to avoid him; and having also examined the dress, his countenance would either assume an expression of pleasure, or, on the contrary, he would turn away in apparent disgust, and retire to a distant part of the room.

That odour is a quality of bodies which can only be made known to us by the sense of smelling is

one of the many proofs of the truth of Locke's opinions, and of the absurdity of the doctrine of innate ideas. Do sight, hearing, seeing, taste, or imagination reveal to us the scent of the rose or of the carnation? Certainly not; for we often gather a beautiful flower under the expectation that it has a sweet odour, and find it scentless; and many which are sweet to the smell are bitter to the taste. There exist, however, many substances which are either alike agreeable or disagreeable to the taste and to the smell as well as to the sight; in which case, although we cannot obtain correct ideas of their various properties by one of these senses alone, yet, as each causes us to shun the object of its aversion, even if we should lose two of them, the remaining one would be sufficient to warn us against the poisonous herb or reptile; and thus to accomplish one of the great offices of the external sensations.

Odours are agreeable or the contrary, in proportion to the irritation which they produce in the nostrils; though, by custom, we often become reconciled to scents which were at first disagreeable.

δ. *Of Hearing.*

1. Of Sound.

Sound is most commonly the result of vibrations in the air, produced either by its own expansion, or by the impetus which is given to it by

the movements of certain bodies: and the apparatus of hearing is adapted to collect sounds, and to transmit their impressions to the brain. Air is not indeed the only medium through which sound is conveyed; for all elastic bodies are capable of propagating sonorous vibrations. Sound, however, requires a vehicle for its transmission, and cannot exist in a vacuum. Hence, if a bell be rung under water, it is distinctly heard; but if it be rung while suspended in a receiver which has been exhausted by the air-pump, no sound is audible. The intensity of sound varies in proportion to the condensation of the air, being greatest when the air is most condensed; and for this reason the loudest noises are produced by those circumstances which create the most powerful vibrations, and therefore most forcibly compress the elastic medium in which they move.

The vibrations which commence in these elastic bodies are communicated from particle to particle, alternately advancing and retiring like the waves of the sea; but, being gradually enfeebled by the resistance which they encounter in their progress, they at length die away. The velocity of sound has been differently estimated by the various authors who have investigated this subject. Newton says that it travels at the rate of 968 feet in a second; Mersenne, at 1474; Duhamel states it at 1338; Flamsteed, Halley, and Denham, at 1142; and Cassini de Thury, who had witnessed numerous experiments which were made by firing cannon at

various distances, in all kinds of weather and under a great variety of circumstances, considers the average speed of sound to be 1107 feet in a second. Dr. Roget's estimate differs very little from the latter calculation; for he says the "velocity in air is on an average about 1100 feet in a second, or 12½ miles in a minute: it is greater in dense and smaller in rarefied air; being in the same medium exactly proportional to the elasticity of that medium." He further remarks that, according to Chladni, the velocity of sound in water, which is the medium of it to aquatic animals, is about 4900 feet in a second.

The tone of sound depends upon the number of vibrations which take place in a given time; the acute sounds arising from numerous vibrations repeated in quick succession, and the tone becoming *grave* in proportion to the diminution of their number. Euler was of opinion that the human ear is unable to distinguish any sound that consists of less than 30 vibrations, or more than 7520 in a second; but Magendie says, that the gravest sound which the ear is capable of perceiving is formed of 32 vibrations in a second, and the most acute, of 12,000 in a second; while the investigations of Savart place the maximum at 24,000, and the minimum at 8 vibrations in a second. Upon the force and succession of the vibrations depend the various notes of music. Sir J. Herschel observes, that "whenever an impulse of any kind is conveyed by the air to our ears, it produces the impression of sound; but when

such impulse is regularly and uniformly repeated in extremely rapid succession, it gives us that of a musical note, the pitch of the note depending on the rapidity of the succession. The sense of harmony too depends on the periodical recurrence of coincident impulses on the ear, and affords perhaps the only instance of a sensation for whose pleasing impression a distinct and intelligible reason can be assigned."*

One of the most curious phenomena connected with sound is the power which a sounding body possesses of communicating tremors to distant bodies. Thus, the vibrating movement of one musical chord produces vibrations and sound in others, whose tension and structure is such as to keep time with the pulsations of the air which are propagated from that which was first set in motion. The experiments of Savart show that this principle is also applicable to the elastic membranes; which, like the wires of a musical instrument, are affected by the vibrations of parts in their vicinity; but that this property varies in degree according to the structure, tension, humidity, and other qualities of the membrane. Sound is reflected by bodies through which it cannot pass; the angle of reflection being equal to that of incidence. We also find that its force is increased by concentration; for by the use of a trumpet hearing is facilitated, and the voice becomes audible at a much greater distance

* Discourse on the Study of Natural Philosophy, p. 248.

than it could otherwise be heard. For the same reason, a given quantity of gunpowder, when fired from a gun, produces much more noise than if it had exploded on the ground.

2. Of the Organs of Hearing.

The organ of hearing consists of the external, the middle, and the internal ear.

The external ear includes the pinna, the lobus, and the meatus auditorius externus.

The pinna, which forms the greater part of the external ear, consists of fibro-cartilage, invested by a thin and dry skin, which adheres to it by cellular membrane. On its external side there are four prominences, called the helix, antihelix, tragus, and antitragus; and a projection on its lower part, which is not cartilaginous, but is composed of adipose substance, is termed the lobulus. It contains three cavities, namely, the fossa navicularis, the fossa innominata, and the concha. The pinna is united to the head by an anterior, a posterior, and a superior ligament, together with cellular tissue; and its contraction and expansion are effected by means of several small muscles. The integuments of the pinna are plentifully supplied with sebaceous glands which secrete a white matter; and owing to its numerous nerves, as well as blood-vessels, it is possessed of considerable sensibility.

The meatus auditorius externus extends from the concha to the membrana tympani, and is directed inward, forward, and upward. It is a pipe of about

an inch in length, wider at the ends than in the middle, and consists partly of cartilage, which is a continuation of the pinna, partly of a fibrous substance, and partly of a portion of the temporal bone. Its external orifice is usually surrounded by hairs; and its lining is formed by the prolongation of the skin which, extending from the concha along the tube, terminates by covering the external surface of the tympanum. Under the lining, numerous sebaceous glands are situated, for the purpose of secreting wax, which is poured into the meatus externus. This wax consists of colouring matter, albumen, oil, soda, and phosphate of lime. It is of a yellow colour, and exceedingly bitter.

The external ear is furnished with nerves from the third division of the trifacial, from the portio dura, or seventh cerebral nerves; and from the cervical plexus.

The middle ear comprehends the tympanum with its appendages, the Eustachian tube, and the mastoid cells. The tympanum is a cavity of an irregular form, resembling a part of a cylinder, and is situated in the petrous portion of the temporal bone, between the meatus auditorius externus and the labyrinth. Its outer wall is formed by the membrana tympani, and its inner by a bony partition. The membrana tympani, or membrane of the drum of the ear, is fixed in a groove of the temporal bone, at the extremity of the meatus externus. It is of an oval shape, slightly concave outwardly; and composed of an external membrane, which is a prolongation of

the lining of the meatus externus; of an internal membrane continuous with that lining the cavity of the tympanum; and of a middle muscular layer, the fibres of which converge from the circumference, and are inserted into a small bone called the malleus. The chorda tympani, which is a branch of the vidian nerve, crosses the cavity of the tympanum.

Toward the upper part of the bony partition of the tympanum, there is an oval aperture called the fenestra ovalis, which forms a communication between the tympanum and the vestibule and semicircular canals; toward its lower part is also another aperture, the fenestra rotunda, which forms a communication between the tympanum and the cochlea; both these apertures being closed by membranes. Over this is a projection termed the promontory; and behind the fenestra ovalis is the pyramid. The Eustachian tube, whereby the tympanum and pharynx are connected, and the mastoid cells, which like the tympanum itself contain air, also open into this cavity. The mucous membrane, which lines the tympanum, the mastoid cells, and the Eustachian tube, is continuous with the mucous lining of the pharynx. The tympanum contains four bones, namely, the malleus, incus, os orbiculare, and stapes, which form a chain from the membrana tympani to the membrane closing the fenestra ovalis; the malleus being situated on the former, and the stapes being fixed to the latter. They are moved by means of several small muscles, which are attached to them for that purpose. The middle ear receives nervous

filaments from the spheno-palatine and otic ganglia; from the ramus anastomoticus of Jacobson, and from the trifacial nerve.

The inner ear or labyrinth comprises the vestibule, the cochlea, and the semicircular canals. The vestibule occupies the centre of the internal ear, being situated behind the cochlea and before the semicircular canals. It is of an irregular oval figure, and communicates with the tympanum by means of the fenestra ovalis; with the cochlea, with the semicircular canals, with the aquaductus vestibuli, and with the bony canal called the meatus auditorius internus, which forms a passage for the seventh and eighth cerebral nerves, as well as for a small artery.

The cochlea is a bony cavity situated in front of the vestibule. It is divided into two canals which are termed the gyri or scalæ of the cochlea; the one communicating with the vestibule, the other with the tympanum, being however separated from it by the membrane which closes the orifice of the fenestra rotunda. The aquaductus cochleæ opens into this cavity.

The semicircular canals are three cylindrical cavities placed behind the vestibule, in which they terminate; and each of them contains a small membranous tube, united to its walls by a very fine cellular membrane.

All the cavities of the internal ear are lined by a thin membrane, and are filled with a limpid fluid. The eighth cerebral nerve, which arises from the

floor of the fourth ventricle of the brain, is distributed to the cavities of the internal ear, on the membranous lining of which it terminates by very minute branches, softened down into a pulp resembling the retina. Animals do not manifest any signs of pain when this nerve is cut, or otherwise lacerated.

3. Of the Physiology of Hearing.

The uses of the various parts of the ear are not clearly ascertained; and the accounts which are given of the physiology of hearing must therefore be somewhat hypothetical. It seems probable, however, that the sonorous vibrations are collected by the pinna, and thence are conveyed into the meatus externus. In man the external portion of the ear is stationary, but in animals it is very mobile. Thus at the report of a gun or any other noise, the horse and the dog prick up their ears, and direct their orifices towards the quarter whence the sound appears to have come. The pinna is not however absolutely indispensable to hearing, for this sense is not destroyed by its removal. The meatus auditorius externus condenses the sound, and transmits it to the membrana tympani. The wax which is secreted by the lining of this tube, and the hairs with which it is furnished, present an obstacle to the entrance of insects, dust, &c. &c. The sonorous vibrations arriving from the external ear excite vibratory motions in the membrana tympani, the tension of which is regulated by its muscles;

and, as Magendie remarks, it is probably relaxed for weak or agreeable sounds, and becomes stretched for those that are too intense or disagreeable; inasmuch as in the former state it would vibrate more freely than in the latter. This membrane, while it facilitates the progress of sound, also prevents the admission of extraneous particles into the middle and internal chambers of the ear.

From the membrana tympani, the sound is transmitted through the tympanum to the internal ear by two channels: 1st. The vibrations of this membrane are communicated to the air in the cavity which produces corresponding movements in the membrane of the fenestra rotunda; the air in the tympanum having access to the external atmosphere through the Eustachian tube, so that their temperature can never differ sufficiently to allow of any injury to the ear-drum from atmospheric pressure; every variation of which would otherwise endanger its delicate structure. Nevertheless, it is the opinion of some eminent physiologists, that the air in the tympanum preserves an uniform heat, which is conducive to the safety and the functions of the internal ear. 2d. The vibrations are conducted by the chain of small bones to the membrane of the fenestra ovalis. Savart observes, that since all the small bones are united together, to enable the first to touch the membrane of the tympanum, and the last the fenestra ovalis, and since the malleus moreover is capable of some motion, in order to prevent laceration, a mobility of the small pieces composing

the chain is indispensable. Thus, when the malleus is carried backward, that movement advances it to the stapes, which compresses the fluid contained in the labyrinth; whence it would result that the extent of the oscillations of the membrane of the fenestra rotunda must become more confined. "In short," he says, "I believe that the chain of small bones is to the ear the same as the bridge to the violin."*

The motions of these bones, as Dr. Todd has conjectured, are probably regulated by the nerves of the otic ganglion, which is excited to action by the stimulus of sound.

Sounds are also conveyed from the membrana tympani to the labyrinth, by the bony walls of the tympanum, and their intensity is increased by the mastoid cells.

The sound, having at length reached the internal ear by the means which I have described, excites undulations in the fluid contained in its cavities; these undulations produce impressions on the extremities of the eighth cerebral nerves, which from the distribution of their filaments to the labyrinth are considered to be the auditory nerves, and a corresponding sensation is produced in the brain.

Such is probably the course which sound pursues when travelling through the passages of the ear; but we know nothing of the peculiar office of each portion of the labyrinth, which is the only essential

* See Magendie's Physiology, and Journal de Physique.

part of the organ of hearing. Magendie conceives it necessary that the fluid in these cavities should give way to those impressions which are too intense, and which might injure the acoustic nerve; and that in this case it may flow into the aqueducts of the cochlea, and of the vestibule, which so far would have a great analogy to the Eustachian tube. Dr. Roget conjectures that in the arrangement of the semicircular canals, the object is to allow of the transmission of vibrations of every kind in whatever direction they may arrive. He thinks it not an improbable supposition that the return into the vestibule of undulations which have passed through these canals, has the effect of at once putting a stop to all further motion of the fluid, and preventing the continuance of the impression which has been already made on the nerves. The same use, he says, may be assigned to the double spiral convolutions of the tubes of the cochlea.* Weber imagines that the cochlea is intended to place the extremities of the acoustic nerve in connexion with a vibrating solid; and that the use of the semicircular canals is to form a connexion with a vibrating fluid, and to receive the impulses of the air through the meatus auditorius.† All this is, however, purely hypothetical; but pathology affords some facts which are deserving of notice.

Hearing is very little affected by removal of the pinna; but obliteration of the meatus externus

* Fifth Bridgewater Treatise, vol. ii. p. 433.

† See Elliotson's Physiology, p. 555.

causes deafness. Perforation of the membrana tympani does not impede its function; while the entire destruction of it impairs but does not permanently destroy the sense; which Sir A. Cooper explains by the supposition that in such instances the functions of this membrane have been carried on by the membranes of the fenestra ovalis and fenestra rotunda.* Destruction of the small bones of the ear renders the hearing indistinct, but does not annihilate it; whereas stoppage of the Eustachian tube, paralysis of the auditory nerve, or deficiency of the fluid by which its fibres are lubricated, rupture either of the membrane which closes the fenestra ovalis or of that which closes the fenestra rotunda, is inevitably followed by deafness.

From these circumstances it is obvious that although the perception of sound is most accurate when each part of the ear performs its allotted duty, yet that the complicated structure of this organ as developed in man is not absolutely necessary for the exercise of the sense.

This is also proved by comparative anatomy; for in many of the lower animals the apparatus of hearing simply consists of a bony cavity or vestibule, lined by a membrane, and furnished with a nerve. Such is the ear of the cephalopoda, which is the only family of mollusca that possess this organ, while in fishes we usually find the semicircular canals as well as the vestibule; and in addition to

* See Philosophical Transactions, 1800.

these parts, birds have likewise the cochlea and tympanum.

Sound commonly enters both ears at the same time, but produces only one impression on the brain, which may probably be attributed to the union of the roots of the two auditory nerves at the median line and to the simultaneous occurrence of the two sensations. Nevertheless, we are able to judge of the direction from which sound proceeds, by comparing its effect on the two organs; for the vibrations will of course act more forcibly upon that of which the orifice is turned towards them, than upon that which opens in another direction; and for the same reason, sounds from the front affect the ear more powerfully than those from the back of the head. In all these cases, however, the ear is materially assisted by the sight, and requires experience to mature its perception; for the mind cannot derive accurate information from any of the senses until the faculties of the brain are so far perfected by exercise that it can analyze, compare, and combine the impressions which are conveyed to it. Thus, by comparing the sensations of sight, hearing, and feeling, we obtain ideas of distance which could not be communicated to us by any one of the senses alone. For example, if a child were for the first time to hear the report of a gun, without being able to see the piece, there would be no possibility of its determining whether the explosion had taken place within a hundred yards, or at the distance of half a mile; whereas, if the gun

had exploded in its hand, or if it had witnessed the act of firing, the idea of distance would be perfectly distinct.

The voluntary motions are singularly influenced by the sense of hearing; whence, in all ages, music has been deemed of the greatest utility in measuring the step of troops when on the march. Such, indeed, is the association of certain sounds with certain actions, that the step is unconsciously accelerated or slackened in accordance with the vibrations on the ear.

The ear is one of the great channels through which the mind receives that portion of knowledge which is imparted by language; and it is also the principal director of the voice. So essential indeed is hearing to speech, that those who are born deaf are also invariably dumb; but if by any fortunate accident hearing be restored, the power of articulation is very soon acquired. Means, indeed, have been devised by which deaf persons may be taught to speak, but they are seldom able to modulate the voice, which is consequently unequal in its tones, and deficient in expression; though there have been some rare exceptions to this rule. I was some years ago acquainted with a young lady who, though completely deaf, possessed a very harmonious voice, and spoke with perfect accuracy. She had the accent of a well-educated foreigner, and by observing the motion of the lips of those who addressed her, could take a part in conversation. She also read aloud exceedingly well; and in short displayed a

control over the organs of speech which can only be accounted for by supposing that in her case the muscular sense was so acute as to supply the place of hearing by informing the mind of those movements of the larynx which are usually made known to it through the ear.

This curious exception to the ordinary and natural consequences of deafness does not, however, detract from the importance of hearing; and any one who has seen the letter of a deaf and dumb person must have observed how much the mind loses by the want of this sense: for, being deprived of the ideas which are associated with articulate and musical sounds, and which exercise so great an influence over the imagination, their compositions are usually deficient in connexion as well as in harmony of style.

It has long been a question, upon what depends that passionate love of or, as it is called, *ear for music*, which some people possess in so much greater a degree than others?

Buffon, after examining a number of persons who had no ear for music, says that every one of them heard worse with one ear than with the other, and ascribes their inability of distinguishing musical expression to that defect; but Smellie, who regards this faculty as "a gift of nature," remarks that a musical ear seems to have no dependence on either acuteness or bluntness of hearing whether in one or both ears; since there are many examples of people who may be said to be half deaf, and yet are

both fond of music and skilful performers. (See the Physiology of Natural History.) The deafness of the great composer Beethoven seems to afford an illustration of Smellie's observation; but the facts mentioned by Buffon are well worth attention; for while, I conceive, that if both ears were *equally* affected, the individual would be able to appreciate sound, though the tones would appear lower than to other persons, disorder of *one ear only* would destroy the unity of the impression; the sensation of one organ would be more intense than that of the other; the brain would receive two impressions simultaneously, and thus notes which would otherwise appear harmonious, would afford discordant sounds.

ε. *Of Seeing.*

1. Of Light.

By the sense of seeing we are enabled to estimate the position, figure, colour, and magnitude of bodies, without coming in contact with them; and light is the medium through which objects are presented to the eye.

There are two theories respecting the nature of light: for one of which we are indebted to the genius of Newton, and for the other to Huyghens, who lived about the same period as the great British philosopher. By the first of these hypotheses, it

is regarded as a substance composed of very minute particles, which are constantly emanating from luminous bodies, so as to form a continuous stream or ray; while Huyghens, whose opinion was advocated by Euler, supposed it to consist of a subtile and highly elastic fluid, wherein luminous bodies produce undulations which move in a similar manner to the vibrations of sound. Without, however, entering into the comparative merits of the corpuscularian and undulatory theories which, notwithstanding the powerful arguments that have been adduced on each side by men of first-rate abilities, still divide the scientific world, it will suffice for our purpose to consider those properties of light which more immediately affect the organs of vision.

Light travels at the rate of 192,000 miles in a second, and pursues a straight direction, unless it be interrupted in its course. If an opaque body be the obstacle, the ray, being unable to enter it, unless absorbed, is turned back, and is said to be *reflected;* in which case the angle of reflection is invariably equal to the angle of incidence. If, on the contrary, a ray of light come in contact with a transparent body, which is of a different density to the medium which it has previously traversed and fall upon it obliquely, it is bent or *refracted;* but if it pass perpendicularly from one medium to another, it continues to move forward, without changing its direction. Transparent substances, however, reflect as well as refract. When a ray of light proceeds from a rare medium into one which is comparatively

dense, it is refracted toward the perpendicular, and vice versâ; the degree of refraction varying in proportion to the density and combustibility of the medium, while the disposition of the rays is modified by the shape of the refracting body. Thus, double convex lenses, such as the crystalline, have the power of collecting into a focus the rays which pass through them; and some crystals possess the property of producing double refraction, or of splitting the rays which enter them into two parts: one of which is refracted in the usual manner, and remains in the plane perpendicular to the refracting surface; while the other deviates from this plane, thus undergoing what is termed *extraordinary refraction*. By decomposing solar or white light, it is found to consist of various kinds of rays, which differ both in colour and refrangibility. Of these, the first class or red rays are least refrangible; next come the orange, then the yellow, the green, the blue, the indigo, and the violet; the last being the most refrangible of all the seven. The property of absorbing light is extremely various in different substances; and hence arise the distinctions of colour. Thus, a white body reflects all the rays which may fall upon it; red reflects the red rays, and absorbs the rest; and so with the other colours, except black, which absorbs all the rays. It would appear, therefore, that the colour of a body depends upon the rays which are reflected from its surface. The rays of light differ also in their power of illuminating objects; for it is found by experiment that

the green and yellow rays possess this faculty in a much higher degree than the rest; it is in fact greatest in the middle classes of rays, and least in the first and last classes; that is, the red and violet.

2. Of the Organs of Vision.

To receive the impressions which are conveyed to them through the medium of light, the higher orders of animals are provided with organs which, being specially adapted to this purpose, concentrate the rays so as to present a distinct set of images to the brain. The apparatus of vision, which consists of the two eyes and the optic nerves, is so extremely delicate in structure, that if it were exposed to the same accidents as other external parts, scarce a day would elapse without the occurrence of some serious injury. To obviate this inconvenience, nature has provided the eyebrows, the eyelids, and the secreting and excreting apparatus of the tears, which protect the eye, without offering any impediment to the perfect exercise of its functions.

The eyebrows are two arches, consisting of adipose tissue covered with hairs, and situated upon the ridges of the frontal bone, which are immediately above the eyes. They are supplied with nerves from the first branches of the trifacial, and are moved by the occipitofrontalis and corrugatores supercilii muscles. By the projection which they form, the eyebrows shade the eyes from too much light, and assist in defending them from external contusions; while their hairs turn away from these organs the

perspiration which may flow down the forehead, and which might otherwise irritate their surface.

The eyelids are situated in front of the eyeball, which when closed they completely cover; but the upper one being much larger as well as more mobile than the lower, they meet below the median line. They are composed of the orbicularis muscles, which by contracting draw them together, thus shutting up the eye; of cellular membrane; of mucous membrane which lines their inside; of very thin transparent skin which covers their external surface; and of the fibro-cartilages called tarsi, which are placed in the edges of the eyelids for the purpose of preserving their form, and extending them so as to suit the shape of the eye. Underneath the tarsi there are numerous very minute follicles, termed the Meibomian or ciliary glands, which secrete an unctuous matter, to lubricate the edges of the eyelids, to diminish their friction, and to prevent their agglutination during sleep. Each edge of the eyelids is also furnished with a row of strong hairs, which are named eyelashes or cilia: those of the upper eyelids turn upward, while those of the lower eyelids, which are shorter than the others, turn downward. In addition to these parts, the upper eyelids are provided with the levator palpebræ superioris muscles, which serve to elevate them, and thus open the eye. The eyelids receive filaments from the trifacial nerves, which are the conductors of their sensations, and from the seventh pair of cerebral nerves, which are the regulators

of their movements. The levator muscle is also supplied with some twigs from the third pair of cerebral nerves.

It is the office of the eyelids to protect the eye from the contact of extraneous bodies; to prevent the entrance of too large a portion of light, and limit it to that which is necessary for vision; and to preserve the brain during sleep from the action of a stimulus, which is of all others most destructive to repose. These objects are further promoted by the eyelashes, which assist in shading the eye from too intense light, and in preventing the admission of small particles of dust and other substances.

The apparatus for secreting and carrying away the tears consists in each eye of the lachrymal gland, with its secretory ducts, the caruncula lachrymalis, valvula semilunaris, the puncta lachrymalia, the lachrymal ducts, the lachrymal sac, and the nasal duct.

The lachrymal gland is a small body of an oval shape, which is situated in a depression of the frontal bone at the anterior, superior, and exterior part of the orbit. It has several excretory ducts, which descending upon the tunica conjunctiva, at length penetrate it near the superior tarsus, so that the tears which may be secreted by the gland flow from these canals over the surface of the eye.

The tears are a saline, muco-serous fluid, which, according to Vauquelin and Fourcroy, are composed of water, mucus, soda, muriate and phosphate of soda, and phosphate of lime.

The caruncula lachrymalis is a small red pyramidal body, placed between the inner angle of the eyelids and the eyeball. It is formed by several small follicles, each of which has an orifice containing a very minute hair, and is invested by folds of the conjunctiva. The carunculæ appear to secrete a peculiar oily matter, which lubricates the edges of the eyelids; and they probably assist in hindering the tears, which are very liable to accumulate at this spot, from flowing down the cheeks.

Immediately on the outer side of the caruncula, an indistinct fold of the conjunctiva may be observed, which, from its situation and resemblance to a similar but much more developed structure in certain animals, has been termed the membrana nictitans or valvula semilunaris. It directs the tears towards the puncta lachrymalia.

The puncta lachrymalia are two small apertures, one of which is situated on each of the eyelids, very near their inner angles, and at the point where their edges change their direction. They are surrounded by a firm structure which keepstheir orifices always open, and constitutes the mouths of the lachrymal canals. These canals open into the lachrymal sac, which is a small membranous bag, lodged in a bony groove at the inner angle of the orbit. This sac communicates with the cavity of the nose by means of the nasal duct, which thus affords an outlet to the tears that have been absorbed by the puncta lachrymalia, and poured into the sac through the lachrymal ducts.

From the account which I have given of the course pursued by the tears, it would seem that they are secreted by the lachrymal gland, flow through the excretory ducts, over the anterior surface of the eye, every part of which they lubricate, are absorbed by the puncta lachrymalia, whence they pass through the lachrymal ducts into the lachrymal sac, and are finally conveyed by the nasal duct into the cavity of the nose. The lachrymal apparatus is supplied with nerves by the first branch of the trifacial. Secretion of tears may be produced either by irritation of the eye, or by mental emotions. It is their office to wash away from the surface of the eye any rough, acrid, or other irritating matter, which may enter between the eyelids.

The eye is composed of membranes, humours, blood-vessels, nerves, and absorbents.

The tunica conjunctiva is a thin transparent membrane, which belongs to the mucous system; it not only covers the interior surface of the eyelids, but also the anterior surface of the globe of the eye, at the inner canthus of which it forms a remarkable fold, called the valvula semilunaris. It lines the puncta lachrymalia, and forms both the lachrymal sac and the nasal duct, where it is continuous with the Schneiderian membrane. At the free edges of the eyelids, the tunica conjunctiva is continuous with the cutis, and is pierced by the ducts of the Meibomian glands. It receives filaments both from the lachrymal and external nasal

branches of the trifacial nerve, which render it highly sensitive; and it secretes a mucous fluid which mixes with the tears. The uses of the conjunctiva are to unite the eye to the lid, to facilitate the movements of the eye by means of its smooth moist surface, which enables the ball to roll round without suffering friction, and to assist in protecting it from the action of the air, dust, &c., and to prevent foreign bodies from passing into the orbit.

The tunica sclerotica is a hard fibrous membrane, which, together with the cornea, forms the external coat of the eyeball. Besides defending the internal parts of the organ, it presents a surface for the insertion of several muscles by which the eye is moved.

The choroid membrane, which is the most vascular coat of the eye, is situated immediately within the tunica sclerotica, and is covered with a dark-coloured substance called pigmentum nigrum, which it is its office to secrete. It terminates anteriorly at the ciliary circle, which is a grayish ring placed between the choroid membrane, the sclerotica, and the iris. From this circle project several small white bodies, called the ciliary processes, which are arranged in a radiated form behind the iris. The use of these parts is unknown. Haller supposed that they assist in supporting the lens; while Edwards is of opinion that they contribute to the secretion of the aqueous humour. M. Ribes agrees with Mr. Edwards, but thinks that in addition to this function they support life and motion in the crystalline and

vitreous humours. Magendie, however, remarks that these humours exist in animals which have no ciliary processes.*

The iris is a circular membrane, the circumference of which is attached to the ciliary circle and processes. In its centre there is an aperture, termed the pupil, the size of which is regulated by the contractions of the iris. The iris has a muscular structure, and consists of two layers of fibres; of which the external layer is radiated, and has the power of dilating the pupil; while the other being concentric diminishes it. The dark substance of the choroid membrane is prolonged at the posterior surface of the iris, to which it gives a darker or lighter appearance, in proportion to the thickness of the muscular layers, which are thereby rendered more or less transparent. It receives filaments from the trifacial nerve, from the ophthalmic ganglion, and from the ciliary body. The use of the iris is to exclude the superabundant rays of light; and by varying the size of the pupil, to admit such a portion as may assist vision without over exciting the sensibility of the retina. The iris may be called into action either by impressions on the brain or by the influence of light upon the eye; in the former of which cases the cerebrum acts upon the muscle through the medium of the third pair of cerebral nerves, which send fibres to the ciliary ganglion and iris; in the latter the stimulus is, according to

* Magendie's Physiology.

Müller, conveyed from the retina along the optic nerve to the brain, and thence along the third cerebral nerve to the iris; whereas Mr. Grainger seems to think that the stimulus is transmitted by those fibres of the optic nerve which go either to the optic tubercles or to the thalami, and is thence reflected upon the iris. The mode in which this is effected will be better understood, when we treat of the involuntary motions. It was formerly supposed that the motions of the iris were dependent on the ophthalmic ganglion; but the experiments of Mayo clearly show that the second and third cerebral nerves are the principal agents in regulating its movements.

We now come to the refractive parts of the eye. The first of these is the cornea, which is a transparent plate forming the anterior portion of the eyeball, convex externally, concave internally; and, as connected with the sclerotica, has some resemblance to a watchglass fixed in the edge of its case. Situated behind the cornea, and before the crystalline lens, is a transparent fluid called the aqueous humour, which, according to Magendie, consists of the muriates of soda and potassa; the lactates of soda and potassa, soda, albumen, animal matter, and water. It is enveloped by a membrane, and the space which it occupies is divided by the iris into two chambers, which communicate together through the pupil. Taking the refractive power of water at 1·3358, Sir D. Brewster computes that of the aqueous humour at 1·3366. Opposite to the pupil

and at the back of the aqueous humour lies the crystalline lens, which is a small oval body, composed, according to Berzelius, of water; the muriatic, phosphoric, and lactic acids in combination with alkalies; animal matter; and a peculiar substance which possesses the same chemical properties as the colouring matter of the blood, except its colour. Its posterior surface is more convex than the anterior; its texture is gelatinous, and much harder at the centre than at the circumference; it consists of concentric layers; and is surrounded by a very thin membrane. Its refractive power is 1·3839.

The vitreous humour occupies all that part of the eyeball which is behind the lens and before the retina. It is a gelatinous, transparent substance, consisting of albumen, soda, the hydrochloric and lactic acids combined with bases and water; and is surrounded by the hyaloid membrane, which also penetrates the humour in various directions, so as to divide it into cells. The refractive power of the vitreous humour is 1·3394. This is the last of the refracting portions of the eye; but it still remains for me to mention the parts by which visual impressions are carried to the brain.

The retina is situated between the choroid coat and the hyaloid membrane, though there also lies between them Jacob's membrane. The retina extends from the optic nerve, nearly as far forwards as the corpus ciliare, within about two lines of which it terminates by a distinct edge. Its structure

is soft and pulpy, and appears to be formed of two layers: the outer layer being medullary, the inner layer vascular, and called the tunica vasculosa retinæ. Jacob's membrane is a distinct serous tunic, covering the internal surface of the choroid coat, and the external surface of the retina.

Directly in the centre of the inner surface of the retina, and a little outward of the optic nerve, there is a small yellow spot with a hole in its middle. This, however, is only observed in man, in the ape, and in some reptiles. It has been discovered in several kinds of lizard, and is very clearly seen in the chameleon.

The optic nerves, on the way from their origin to their termination, decussate; but whether some only of the fibres of the inner segment of each are transmitted to join the other, or whether they entirely cross one another, is not determined. The latter supposition appears, however, to be most probable;* for if the corpora quadrigemina on one side be destroyed, the eye on the opposite side becomes blind; if one of the optic nerves be divided behind their decussation, the sight of the eye on the other side is destroyed; and if the point at which they meet be cut so as to separate the one from the other, total loss of vision is the immediate result. It would seem, therefore, that the objects which enter either eye, and are imprinted on its retina, pass along the optic nerve to the opposite

* Experiments of Magendie and Flourens.

hemisphere of the brain; while some of the rays of light also act upon the iris of the eye through which they were admitted, in the manner that I have already described. The retina and the optic nerve are insensible to ordinary stimuli, such as pricking and tearing, although they are most painfully affected by exposure to highly luminous bodies.

Since all the light which comes in contact with the white and opaque parts of the eyeball is reflected, those rays which fall upon the cornea can alone be visible. Hence, it is necessary that we should have the power of turning its transparent portion towards whatever objects we may desire to inspect; so that the image may be opposite to the centre of the retina, that being its most sensitive part. This is done by means of six muscles, all of which arise from the bottom of the orbit, and are inserted into the sclerotica. Of these, the rectus oculi superior raises the eye; the rectus inferior depresses it; the rectus internus draws it inwards; and the rectus externus turns it outwards. If all the recti muscles act simultaneously, the eyeball is drawn toward the back of the orbit; and if two of them contract at the same time, they modify the movements which they would have individually produced.

Of the other two muscles of the eye, the obliquus superior oculi or trochlearis rolls the eyeball, so as to direct the pupil inwards and downwards,

while the obliquus inferior oculi directs the pupil upwards and outwards. By the joint action of the oblique muscles, the eye is carried forwards; so that they are antagonists to the recti muscles.

The rectus superior, rectus inferior, rectus internus, and obliquus inferior, receive branches from the third cerebral nerves; the obliquus superior from the fourth cerebral nerves; and the rectus externus from the sixth cerebral nerves; to which they respectively owe their mobility. The general sensations of the eye, such as that arising from the extension of its muscles in consequence of intense study, are dependent on the first branch of the trigeminus. If this nerve be divided, the sensibility of the eye to all impressions, except those of light, is destroyed; and Magendie also remarked the curious fact, that violent inflammation with suppuration of the conjunctiva invariably followed the operation.

3. Of the Physiology of Vision.

Of the light which falls upon the cornea some rays are reflected by its bright surface, whence arise the images which we observe on the eyes of others; while some penetrate it, and in thus passing from the more rare medium of the air into the denser medium of the cornea are refracted, the external convexity of the latter making them at the same time converge towards the axis of the eye. On entering, however, the aqueous humour, which

is more rare than the cornea, they slightly diverge; but as this medium is denser than the air, they are, upon the whole, concentrated on their passage through these bodies. Part of the light which is transmitted to the aqueous humour coming in contact with the iris is reflected, and so exhibits the colour of that membrane; while the rest, being admitted through the pupil, proceeds to the crystalline lens. The convexity of both its surfaces, together with the greater density of the lens than either the aqueous or vitreous humours, causes considerable refraction of the rays, both as they enter it and emerge from it; and increases their convergence so as to bring them to a focus on the retina. The vitreous humour, however, being more rare than the lens, the rays of light diverge at the point of contact, so as to prevent them from uniting before they reach the bottom of the eye. Some of the rays, instead of penetrating the vitreous humour, are reflected by the lens, and either return through the aqueous humour and cornea, or are absorbed by the dark-coloured matter at the back of the iris.

In addition to its office as a medium for the conveyance of light, the vitreous humour extends the field of vision, by giving expansion to the retina, upon which the image of every object must be formed, before it can produce any sensation in the brain.

In thus traversing the eye, those rays which fall

upon the lower part of the cornea form their focus on the upper part of the retina; while those which fall upon the upper part of the cornea unite on the lower part of the retina; whence it necessarily follows that the figures on this membrane give an inverted representation of objects; and yet to the brain they appear in their real position—a circumstance which has received no very clear explanation, except that of Dr. Alison, who states that this phenomenon is dependent upon the arrangement of the fibres of the optic nerve. On arriving at the retina the light is absorbed by the pigmentum nigrum, which prevents it from being reflected, as would otherwise happen; while the impression which it makes on the ramifications of the optic nerve are communicated through their trunk to the brain.

To a superficial observer the structure of the eye may seem to be more complicated than its functions require; but the imperfections of sight which are occasioned by malformation of any of its parts show that its organization is the best possible for the purpose which it was intended to fulfil. If, for example, the cornea be too convex, by refracting the rays too powerfully, it causes shortsightedness; if, on the contrary, the cornea be deficient in convexity, which it so frequently is in old age, objects which are near to the eye are imperceptible, whereas distant objects are perceptible; for though the refractive power of the organ is so much diminished that it cannot bring to a focus the more divergent rays of

the former, still it is capable of sufficiently refracting those of the latter; all of which pursue a more parallel course. No object can be distinctly visible unless all the rays from it be collected on the same spot of the retina, for if they were to fall upon it in several different places each would present a separate image, or they would be so generally diffused as to create one vague impression.

The arrangement of the various refracting bodies of the eye also obviates the inconvenience which would otherwise arise from each set of coloured rays possessing a different dgree of refrangibility, so that if they were to pass through one lens only, they would be bent at different angles, and would consequently form several different foci. This phenomenon, which is termed chromatic aberration, would impair vision, were not the refracting media which the light traverses in its progress to the retina so adjusted as to counteract it. In passing through any single refracting body, the rays of light are separated and dispersed.

Since, however, the refracting power and the dispersing power of bodies bear no relative proportion, it frequently happening that two substances which refract equally disperse in different degrees, and vice versâ, a series of lenses may be so placed as to neutralize the dispersions of each other. Such is, no doubt, the effect of the various humours of the eye, which though not a perfectly achromatic instrument, is sufficiently so for all practical purposes.

As the rays of light from distant objects are nearly parallel, while those from luminous bodies which are near to us diverge more or less in proportion to their proximity; in passing through a common lens, the former enter it further from the centre than the latter. Hence, the lens being thicker at the centre than at the circumference, the two sets of rays are refracted at different angles, form different foci, and consequently present indistinct images.

This inconvenience, which is called the aberration of sphericity, is however remedied in the eye by the structure of the crystalline lens, which, being denser at its middle than at its edges, equally refracts both sets of rays, and brings them to the same point of the retina.

As the direction in which rays fall upon the eye depends on the distance of the body whence they proceed, some change in the position of the organ itself or in the arrangement of its parts is required to enable it to exercise its function on objects in every variety of situation. This seems to be effected by the muscles of the eyeball, the iris, and the crystalline lens. In viewing objects which are near to us, it is necessary as much as possible to increase the refracting power of the eye, which might be done by rendering more convex the external surface either of the cornea, or of the crystalline lens; and in the opinion of some eminent physiologists, these alterations of shape actually take place through the

agency of the iris, which under such circumstances is invariably contracted. It has also been conjectured that the iris is capable of moving the lens so as to increase its distance from the retina, and thereby allow space for the more divergent rays to meet in one point by the time they reach that membrane. In looking at distant objects, movements the reverse of these would of course be required, unless the eye, while in a state of rest, be better suited to receive parallel than divergent rays.

The remarks which I have hitherto made respecting the phenomena of sight merely refer to the exercise of this sense by a single eye; but it is to be remembered that since we commonly use both eyes at once, a separate image must be formed on the retina of each; and yet we see only one object. This has by some physiologists been attributed to the supposed decussation of the optic nerves; but, as I have already stated, it is very doubtful whether they partially decussate or entirely cross each other.

The real explanation appears to be, that the impressions of luminous bodies affect both eyes simultaneously, and the mind having no time to compare them together, they merge in each other, so as to create a single sensation. The same circumstance takes place with regard to other senses. When, for instance, a person is cupped, he can neither tell how many knives enter the skin, nor describe the precise extent of the wounds; but if the incisions were to be inflicted at intervals, the mind would

compare their intensity, and acquire a correct idea of their relative position.

Ocular spectra, or optical illusions, arise from the causes of deception to which I alluded, when speaking of the external sensations in general, that is, either from a disordered state of the brain, or of the nerve, or from an unusual combination of rays, producing an impression which we are not in the habit of contemplating.

The sense of seeing is not possessed by every class of animals; most of the radiata, several tribes of articulata, and the acephalous, as well as some other species of mollusca, being entirely destitute of eyes. Many of the very lowest animals are indeed evidently affected by light; but as they have no organ with any medium through which it could be transmitted, we can only account for this circumstance, by the supposition that they are sensible of the heat which is generated by luminous bodies, while they have no perception of the luminous rays.

In its simplest form,* the eye consists of a transparent membrane, a small mass of black matter, or pigmentum nigrum, and a nerve; but, as Dr. Roget very justly observes, it is probable that such organs are merely suited to convey general sensations of light, without exciting distinct perceptions of the

* Dr. Roget gives an admirable account of the comparative anatomy of the eye in his Bridgewater Treatise.

luminous objects themselves. In its next grade the organ of vision is furnished with a lens in addition to the membrane, the pigment, and the nerve; and the rays being thereby collected in a focus, doubtless create more definite sensations than the less complicated apparatus.

In ascending the animal kingdom we find the choroid coat, the vitreous humour, and the iris, superadded to the parts which exist in the lower tribes; thus forming an eye which is capable of depicting a distant image on the retina, and of affording correct sensations of all visible objects. Such are the eyes of many of the mollusca and articulata, though in these classes they present considerable variety, both with regard to their internal structure and their number.

Among the mollusca, some, as the leech, possess ten eyes; others, like the snail, have only two, or four, according to the number of tentacula; while, among the articulata, we find some with *stemmata*, or eyes of the simple structure; others with *conglomerate eyes*, which are composed of a cluster of these stemmata; others with compound eyes, each of which consists of an assemblage of perfect, though very minute organs of vision; and others with eyes which have numerous lenses and retinæ, but are covered by one common cornea. Besides those portions of the eye which are found in the lower orders of animated beings, the higher orders also possess the tunica sclerotica and aqueous hu-

mour. The different parts of the organ, however, exhibit considerable variety of form and proportion in the several species.

In fishes and other aquatic animals, the density of the cornea so slightly exceeds that of water, which is the external medium of the light which falls upon their eyes, that however convex it might be, the refracting power would still be very small. To obviate this inconvenience, the crystalline lens is almost spherical and of an extremely dense texture; but there being no necessity for convexity of the cornea, it is much flatter than either in quadrupeds or in birds; and being constantly washed with the water, requires no secretion of tears to cleanse its surface. The aqueous humour is small in quantity, and the iris has very little mobility.

Birds, on the contrary, living in a very rare element, have a very convex cornea, a large quantity of the aqueous humour, and a very moveable iris; while for the protection of the eye from injury during their rapid flight, it is provided with a third eyelid, which is formed by a semi-transparent fold of the conjunctiva, and is called membrana nictitans, as well as with a copious secretion of tears. Thus, we find that in every instance, the organ of vision is adapted to receive a certain portion of light; and to refract it, just so much as the atmosphere which the animal inhabits may require. It is moreover always defended by an apparatus which, being modified according to the nature of the surrounding

element, is calculated to preserve the safety without impeding the functions of the organ.

The ideas which the sense of seeing communicates to the mind are both numerous and important; for though, as I have elsewhere observed, our notions of figure, space, and motion are attainable by touch as well as by sight, there are some objects which can only be appreciated by the eye.

Our estimate of the figure and position of bodies by means of sight simply arises from the shape of the image on the retina; that of a round object being round; of a square object being square, &c. &c. It is also obvious that the size of the impression on the eye must be proportionate to the magnitude or distance of the body by which it is made; whence it happens that the images of bodies in motion are constantly varying.

These ocular impressions are not, however, alone capable of conveying to the mind a correct estimate either of size, distance, or motion; for the image which is depicted on the retina by a large object at a distance, may be of precisely equal dimensions to that of a small body, which is situated near to the cornea; so that without some other means of directing the judgment, our ideas would be inextricably confused. This indeed invariably happens to persons who have just attained the faculty of seeing, as is illustrated by the two cases which I mentioned when speaking of the general phenomena of external sensation, and it can only be remedied by comparing the visible impression, either with our past expe-

rience under similar circumstances, or with the evidence which we obtain from the senses of feeling and hearing; but more especially from the former. Thus, in looking for the first time at a solitary tower or pillar, we are very apt to overrate or underrate its height; but if there be at its side a tree or any other object, of which from our general experience or from actual measurement by the hand, we know the size, by comparing the one with the other we at length acquire a true conception of its magnitude. Hence, an artist who wishes to give an idea of one of the great Indian temples, or of the pyramids, represents a man, a horse, or a camel, standing at its foot; that from our knowledge of the ordinary stature of such animals, we may estimate the immensity of the building. The rocks and mountains of Salvator Rosa, are contrasted with the bandit in the glen beneath; and in the pictures of our countryman Martin, who can forget the striking effect of the figures of Daniel and Sardanapalus, in apposition to the majestic towers of Nineveh and Babylon? So likewise we are able to estimate the magnitude of bodies which are on a level with the eye more accurately than those which are above or below us; because we have more experience in exercising vision under the former than under either of the two latter circumstances; and because objects on a height or at a considerable depth are not easily compared with anything of which we can ascertain the dimensions by the other senses.

Upon a similar principle we judge of distance, by

comparing remote objects with those which are within reach, or with a space which we have already traversed. Our ideas of motion and velocity are acquired by comparing the moving body with some stationary object. For this reason, it is extremely difficult to estimate the speed of birds when flying with the wind; or of a boat gliding down a stream, if the eye be entirely directed toward the bird and the clouds, or the boat and the water; but if we look alternately toward the object and toward some fixed point on the earth, we immediately become aware that the former is moving with a certain rapidity. By thus directing the eye to a stationary point, we are able to detect motions so slight as to be even imperceptible to the sense of feeling. A person walking along the Menai bridge, for example, does not perceive its undulating movement except when agitated by a storm; but if he stand still and fix his eye upon a tree or upon the shore, he will be immediately sensible that the bridge is constantly rising and falling in a wavy line, somewhat resembling the motion of a ship at anchor.

But, if the sense of seeing be of such utility in aiding the touch, as well as in ascertaining the tangible qualities of bodies which are beyond the reach of the hand, of how much greater importance is it in discovering the properties of those luminous substances which no organ except the eye can perceive!

It is, however, remarked by Dr. Reid, that there is very little of the knowledge which is acquired by

sight but may be communicated to a man born blind; and this certainly is true as regards those qualities of bodies which may be detected by the touch as well as by the eye; and in those cases wherein the two senses assist each other; for some blind men have been eminent for their attainments, and skilful in the mechanical arts. Nevertheless, it is proved by such instances as Chesselden's boy, that under these circumstances the ideas obtained by feeling uncompared with visual sensations are extremely incorrect; for the boy did not recognize his cat until he had felt her skin; showing that he had not attained the least notion of her visible properties, even from the description of others.

The sense of feeling, therefore, cannot be considered as a substitute for sight, inasmuch as there are some qualities of bodies which, requiring light for their vehicle, can only be transmitted to the mind by the eye. The great acuteness of the hearing and the touch which blind persons usually acquire, and the concentration of their attention toward these senses, so far perfect the ideas which they furnish, as in some degree to atone for the want of sight; yet, upon the whole, the mind is a considerable loser. They may have just conceptions of number or of harmony, and by reasoning upon them, they may become able calculators or musicians; but of the most sublime works of nature, of mountains, of rivers, or of the sea, they can form no adequate notion; and of all objects which derive

their effect from colour, they must for ever remain entirely ignorant.

There are, as Mr. Locke observes, some ideas which enter our minds by one sense only; and if the organs belonging to it be any of them so disordered as not to perform their functions, they have no postern to be admitted by; no other way to bring themselves in view, and be perceived by the understanding. It is thus with colour, which being produced, as I have explained, by the decomposition of light, is perceptible by the eye, but can affect no other sense; so that, notwithstanding Dr. Reid's assertion that a blind man may, by a kind of analogy, in part supply this defect, it is quite impossible for him to have any correct notion of this quality of bodies.

The perception of colour is of inestimable value, and may be justly considered as second in worth to no faculty with which we are endowed. It enables us to profit by the wisdom of past ages, and to record the fruits of our own experience for the benefit of future generations. Without this faculty the arts of painting and of writing would be unknown to us; for although a mode has been contrived by which the blind may be taught to read, yet if all mankind had been devoid of sight, who could have invented any of these means of communicating knowledge? In truth, it would have been impossible; and the most enlightened of men, in such a state of existence, would have been inferior in mental capacity to the worst-educated classes of our countrymen.

I have, however, merely put an imaginary case; for inferior as our physical structure in many respects is to that of the brute creation, if all of us were deprived of sight, we should be unable to seek or procure food, and the whole human race would soon be extinct. Even under present circumstances, aided as the blind are by the humane endeavours of the benevolent and wise, to ameliorate their condition and to supply such means of instruction as are suited to the senses which they possess, it is obvious that they must still lose the enjoyment which is afforded by the arts of painting, sculpture, and architecture, as well as that which arises from contemplating the beauties of nature; all of which have a tendency to refine the mind.

A vast source of pleasure is unknown to them; and the accounts which they may receive of visible objects can at best be productive of very equivocal knowledge.

Sight has, moreover, a very powerful influence over the voluntary movements. It assists us in preserving the equilibrium of the body, and by enabling us to avoid danger it gives confidence and firmness to the step. The aid which this sense affords in guiding the voluntary motions is remarkably illustrated by many curious cases.

Dr. Yellowly had a patient who, though affected with anasthæsia, or loss of feeling, could securely hold a cup in her hand as long as she kept her eyes fixed upon it, but if she withdrew them from the object it fell to the ground; and Dr. M. Hall men-

tions a person, whose lower extremities being slightly paralysed, could walk safely while his eyes were fixed on the ground, but stumbled if he attempted to walk in the dark.*

It is moreover well known that rope-dancers are obliged, during their performance, to fix their eyes upon some object for the purpose of preserving their equilibrium.

* Hall's Lectures.

CHAPTER X.

OF THE MENTAL FACULTIES.

THE mental faculties may be divided into two classes: 1st, INTELLECT; 2d, the PASSIONS; the former comprehending those operations in which the power of the understanding is exercised; the latter, its affections and dispositions.*

SECTION I.

OF INTELLECT.

1st. OF IDEAS.

a. Of their Origin.

It has already been stated that the brain is the seat of the mental faculties, and that sensation is

* Since my object in pursuing this subject is merely to display the agency of *sensation* in the operations of the mind, the following observations will be as concise as possible; and I beg to refer those who may desire a further explanation of the mental phenomena to the works of Locke, Hartley, Tracy, Reid, Dugald Stewart, and Brown, from which they will be enabled to form their own opinions.

the primary source of all our knowledge.* The impressions thus created in the mind are called ideas, which Mr. Locke defines, Whatever is the object of the understanding when a man *thinks*, or whatever it is which the mind can be employed about in thinking.

From the intimate connexion between the positive sensations and our ideas, it follows that the latter must preserve a constant relation to the former; and we accordingly find that every image which arises in the mind, whether in our dreams or while awake, is composed of objects, or particles of objects, which have been impressed upon the senses. As there is a certain sensation corresponding with every impression which may affect the sensiferous cerebral nerves, so do feeling, tasting, smelling, hearing, seeing, hunger, thirst, and the other sensations respectively excite their peculiar trains of ideas. Each of these sensations is not, however, necessarily confined to a single object; for several objects may be combined so as to convey a single impression; and hence has arisen the classification of ideas into *simple* and *complex:* the former being those which consist of one element, as light, temperature, figure, pain; the latter being those which are composed of many parts, as an army or a forest.

Mr. Locke supposed that all simple ideas are either suggested by the senses or by the internal

* See the remarks on Positive Sensations.

operations of the mind, to which he gave the name *reflection,* while he attributed all the complex ideas to the mental operations alone.

This opinion is, however, in some measure erroneous; for we certainly can entertain simple ideas of things which exist but are never presented to the senses, as an atom and a point; and we receive many complex ideas through the medium of sensation.

Our first ideas indeed are very complex; for at the first view we discover a very small portion of the qualities which the object may possess, and therefore include several in one group. But as we examine things more closely, their minute and less apparent properties attract observation, and our ideas become more simple and individual. Thus, in looking at a landscape or a picture, we do not at first discover each tree, each leaf, or each figure; we in the first place contemplate its aggregate effect; but after the eye has for a time rested upon it, we appreciate its component parts.

In fact, the senses furnish both kinds of ideas, and the mental powers are capable either of combining many simple into one complex idea, or of dividing those which are complex into simple ideas. For, although the mind is in the first instance stored with ideas by the sensations communicated to it by the nerves, yet, having once acquired a stock, it is able of itself to remodel them and thereby give them a new character.

β. *Of their Association.*

Ideas have a tendency to recur to the mind whenever it experiences any sensations analogous to, or connected with those by which they were generated. They display an inclination to succeed each other in the same order in which they first appeared, and in proportion to the force of the impression whence they originally sprung. This phenomenon, which is called the *association of ideas,* is a spontaneous operation, over which the will cannot exert the least control, and may be regarded as a species of sympathy : whereof I shall hereafter speak. Thus, the sweet scents prepared from the rose bring before our mind the image of the rose itself; its beautiful colour, its elegant shape; and this again reminds us of the bee, which so frequently partakes of its juices; and that again of the honey which is extracted from it.

In like manner, the smell of food excites the idea of various eatable substances; a picture of the Italian sky, or of a view in a tropical climate, calls forth ideas of warmth; while representations of the arctic regions remind the observer of the feelings which he has experienced during winter in his own country.

Thus, also, the handwriting of a friend raises up his image before us, and the aspect of the

dead carries the mind on to the contemplation of eternity.

In this way do the most trifling incidents, by giving a stimulus to the mind, often lead to the most sublime trains of thought, or call up the wildest fantasies. This, indeed, is the only mode whereby ideas are reproduced, for there is no regular or periodical recurrence of past images, and unless aroused by some kindred excitement they lie dormant for ever.

Since association recalls those images which have made the deepest impressions more readily than those which are less forcible or interesting, it often happens that the most striking qualities of several different objects simultaneously occur to the mind and form one complex idea, while their other properties are forgotten, or branch off, as it were, in another direction.

Complex ideas may be fabricated by the combination of two or more simple ideas. Thus, by adding together several units we compose the idea of a dozen or a score; and by arranging single letters in a certain order we make words. Sometimes, however, an object may possess one quality which is so much more prominent than any other, that it *alone* recurs to the mind, and thereby creates a simple idea. For example, if I see a green, a red, or a yellow wall, the colour usually makes a more lasting impression on me than any of its other properties, and I obtain an idea of green, yellow, or red, which hereafter may become

coupled with other objects, so as to present to the imagination red horses, yellow houses, or green dragons, none of which I may ever have seen. Hence it happens that the same thing often leaves very different impressions on different individuals; the attention of the painter being directed to its colour, that of the sculptor to its figure, &c. &c.

The images thus wrought by association are termed *abstract ideas*, because they are not immediately connected with any individual thing, and have no reference to any specific object. Our abstract idea of an atom, for instance, has no allusion to any particular particle of any existing substance: it comprehends every kind of matter, but is not specially applied to wood, bone, metal, or to any other solid, fluid, or aeriform body.

Sensation and association constitute the foundation of all the other intellectual faculties; which are, indeed, only modifications of them. Thus,

Attention is the natural result of sensation, and the direction which it may take depends either upon an associated impulse, or upon the comparative force of present impressions; those which are most forcible attracting most notice. For as the more feeble of two sensations, which are experienced at the same time, merges in the more powerful, so do ordinary ideas give way to those which are more interesting and important. The mind having in this manner entered upon certain trains of ideas becomes peculiarly sensible of kindred impressions,

which for some time continue to flow in, to the exclusion of all others.

Memory is secondary sensibility. It is the faculty of recalling the impressions, which have once affected the senses or arrested the thoughts, and again presenting them to the mind. The ideas which may have been casually or laboriously acquired, but for which we have no immediate occasion, give place to others, and are laid up, or as it were put out of the way, until they may happen to be needed. Then memory pours forth its hidden store, and thus supplies food upon which the mind may ruminate.

Those ideas which have originated in the most vivid sensations are most easily remembered; for which reason, our recollection of external impressions is usually more correct than of those which arise from the internal organs.

Memory is entirely dependent upon association; and the artificial means which are sometimes used to assist it always effect their purpose, by presenting to the mind a sensation which has in some way become connected with the subject that we wish to remember.

Thus the sight of a place wherein we have formerly lived recalls scenes that are past, and conversations that have occurred, even after the lapse of many years. The same principle is also exemplified in the anecdote of the Ranz des Vaches, related by Rousseau, who says the air was so much beloved by the Swiss that it was forbidden under

pain of death to play it in their ranks, because it excited among them so ardent a desire to return to their country, that those who heard it melted into tears, deserted, or even died of grief.

What we term memory then, in contradistinction to mere conception, as Brown remarks, "is not a new power, but merely a complex result of different mental capacities, as my complex feeling, when I look at an extensive landscape, and regard the various contiguities, or other local relations of the parts to each other, high or low, above or beneath, remote or near, is a proof indeed that I have the capacity of discerning relations, as well as a capacity of vision, but not a proof of any power distinct from both, and requiring therefore a separate place in our primary classifications of the intellectual functions.

"The relations of time, in this respect, do not differ from the relations of place; our conceptions may be combined with the one as much as with the other; and the remembrance, in every case, is a mere conception, like any other mere conception combined with a certain feeling of relation, and nothing more."

Imagination consists in the combination of ideas so as to form new compounds, and is entirely the effect of association; its creations being a tissue of abstract ideas, which are associated with some object that happens to have arrested the attention. All imaginary figures and scenes are either com-

posed of a simple succession of associated ideas, or of a combination of several different groups of them.

Judgment is an union of association and sensation. It is the faculty of perceiving the properties of ideas so accurately as to ascertain their relations to each other, that is, to compare them.* The power of estimating the relations of mental impressions is indeed a necessary consequence of sensation; for as soon as we perceive two objects it naturally follows that we must feel their resemblances, their differences, and their connexion. If red and green make different impressions on the retina, they must create different ideas; and the mind must consequently perceive certain distinctions between them, or in other words, must exercise its judgment upon them; for to discriminate between two objects and to compare them, it is only requisite nicely to discern their respective qualities. Hence arises all our knowledge of the proportion which one thing bears to another; and as I showed when speaking of the senses, much of our acquaintance with the world around us is obtained by comparing together the different positive sensations, and thus checking the evidence of one of them by the information which we derive from another. The influence of judgment is not, however, confined to the ideas which are immediately received

* On this subject see Tracy's Idiologie.

by the senses; for it likewise sifts those which are produced by association and by memory.

Deduction or *Reasoning* is merely a series of judgments. Take, for example, the following syllogism: All quadrupeds are animals; a dog is a quadruped; therefore a dog is an animal. In pursuing this train of reasoning, we first compare the properties of a quadruped with those which are common to all animals; we next compare the properties of a dog with those of a quadruped; and lastly, we compare the results of the foregoing processes with each other.

Thus, it appears that all the intellectual faculties may be traced to Sensation and Association; so that *thinking* may be defined, the power of perceiving impressions, and of associating them together.

2d. Of the Influence of Education and Language on the Intellectual Faculties.

The law of nature, which has ordained that the external senses shall be invigorated by the moderate exercise of their powers, is equally applicable to the intellectual faculties; hence the vast importance of education in strengthening and enlarging the associations, and thus developing and perfecting memory, judgment, and imagination, and the value of language in promoting association, by presenting to the eye or to the ear signs of ideas that

have formerly occurred either to ourselves or to others. Words assist us in arranging our thoughts in reasoning upon the objects which we perceive through the senses, and in recalling them to the mind.

The memory retains poetical compositions with much more facility than prose; which can only be attributed to the arrangement of words and their sounds. Language, also, enables us to communicate our thoughts even to those who are distant from us, and to record them for the benefit of those who are not yet born.

But, though so inestimable a treasure, I quite agree with Brown, that the use of words or signs is not absolutely essential to reason; for both uninstructed deaf and dumb persons and the higher animals seem to exercise the reasoning faculty, and yet they possess neither written language nor articulated sounds.

The intellectual capacity of different individuals presents as great a variety as their personal appearance; but it is in the power of education to raise them all, and to convert the one talent into ten.

SECTION II.

OF THE PASSIONS.

1st. Of Volition, or the Will.

Volition is the desire to attain some object which our senses and intellect induce us to suppose will

promote the happiness either of ourselves or of others; it is therefore a feeling or emotion which arises from sensation and association, and consequently must be regarded as a passion, inasmuch as it is not an operation, but an affection of the mind.

Volition cannot exist without a motive, and that can only be supplied by intellect. Some physiologists are, however, of opinion that there is a distinction between the *will*—that is, the wish to perform an act—and volition, or the power by which the mind directs the performance of it; but this appears to me to be an erroneous view of the subject. Suppose, for example, that wishing to spend a shilling, upon putting my hand in my pocket I find nothing, but I know where there is one belonging to some other person, which I might appropriate to my own use, yet I do not take it, though my desire to lay out the money is still as strong as it was at first. What then prevents my will from compelling me to follow its dictates? It is my detestation of theft, or perhaps the fear of punishment, which excites another wish that, being opposed to my former inclinations, overcomes the desire which I had entertained, and makes me willing to endure privation rather than commit robbery.

If we were to analyze our own feelings and actions, we should always find that when the will is uncontrolled it can set in motion the organs which are subject to it without any other mental

effort; but we are often conscious of contests in the mind, wherein one volition gives way to another, as the evidence on the different sides of an argument may alternately seem to preponderate. These changes are frequently the cause of that lamentable indecision of character which we sometimes witness; though they are in a certain degree unavoidable, even in the firmest and best constituted minds.

2d. Of the Passions commonly so called.

All those feelings which are commonly called passions, among which I include the moral feelings, are modifications of volition, and are therefore either the result of sensation or of association. They may be divided into two classes, namely, the Sensual and the Social Passions.

a. The Sensual Passions arise either from actual impressions on the organs of sense, or from associations connected with them. Such are,

Love—which, in its simplest form, is the desire of happiness to the object of attachment; but, if associated with sexual sensations, there is moreover the wish to gratify the animal appetite.

Anger and Hatred—which are different degrees of the same passion, imply a desire that injury may

be inflicted on the person who has offended us. Hatred is intense anger, directed against one or more objects; and both arise from a painful feeling, that we have suffered wrong at the hands of another.

Fear is the wish to avoid danger, and originates either in the experience of suffering, or in the supposition that the object of terror is capable of giving pain.

Sorrow is the regret for something that we have lost; or, in other words, the wish for something of which we have been deprived.

These and the other passions of the same class are invariably developed in proportion to the sensibility of the individual, being strongest in those whose sensations and intellect are most acute. I do not mean to say that a clever man is necessarily a coward, or that a nervous invalid is consequently passionate; but, wherever there is the highest degree of sensibility to the impressions which call forth these passions, the tendency to them must be greatest, and is proved to be so by experience.

In civilized society, however, man is taught to curb his feelings; intellect is made to assert its supremacy over the mere animal propensities; but, in the savage state, the passions rage uncontrolled, and are unscrupulously gratified.

β. The Social Passions are creations of the state of society in which we live, and of early education. Such are,

Ambition—which is the desire for power.

Avarice—the desire for riches.

Benevolence—the desire to benefit others.

Gratitude—the wish to make a return for kindness which we have received.

Jealousy—which is caused by the fear of rivalry, and implies a desire either to keep or to obtain some object, often combined with the wish that calamity may befall those who endeavour to thwart us.

The social passions, or moral principles, as they are by many called, have been supposed by some metaphysicians to be innate; but this is clearly disproved by the various and irreconcilable notions of morality which different communities entertain. How different, for instance, is the morality of the savage, whose only virtue is hospitality, from the benevolence and self-denying doctrines of more civilized beings and nations.

To the influence of the passions over the physical functions, I have already alluded; and as I shall hereafter have occasion to enter further into the subject, the consideration of it may, for the present, be postponed.*

* See chap. xv.

CHAPTER XI.

OF THE GENERAL LAWS OF THE ANIMAL MOTIONS.

HAVING traced the phenomena of sensation from their primary causes; having described the laws by which they are regulated; and pointed out their mighty influence on the intellectual faculties; it now becomes us to consider the part which they perform in controlling the physical functions. This indeed is comparatively an easy task; for while the hidden operations of the mind must in great measure be explained by abstract reasoning or vague speculation, the power of sensation over the various organs of the body may for the most part be demonstrated by observation and experiment. We can discover a continuous line of nervous matter from the point where an impression has been made on a sensitive nerve of the spinal system to the medulla oblongata or spinalis, and thence to a part of the viscera, or to a limb which is in motion; and we find that whenever the sentient extremity of this line is irritated, the organ at the other end instantly moves.* In this case the impression stimulates

* Dr. M. Hall speaks of the influence of a stimulus being carried along a nerve to the medulla spinalis, and *reflected* along a motory nerve; but this does not seem to me to be a correct expression. The stimulus is not, I imagine, reflected upon the muscle, but merely excites the nervous centre, and calls forth its energies, as I have above explained.

the nervous centre, which being excited into action exerts its influence upon the motory nerve; and it seems to me probable that in like manner, when a a stimulus is applied to a sensitive ganglionic nerve, (if it be admitted, as I think it must, that this system has, like the spinal and cerebral, two sets of filaments,) its impression is conveyed to the ganglion, which propagates its influence along the motory nerve to the organ. This is not proved by experiment; but provided there be any analogy between the ganglionic and the other parts of the nervous system, it is the only explanation which can be offered respecting its action.

As, in the ganglionic and spinal systems, the impressions upon the sentient extremities of the nerves stimulate the ganglia or the spinal cord, so in the cerebral system do the objects which are transmitted along the nerves of sensation excite the brain. But here the parallel ceases; for while the former immediately call into action the nerves of motion the latter arouse the peculiar functions of the cerebrum, and the ideas therein generated act upon the motory nerve. This may be proved by experiment; for if a motory nerve be cut the part to which it is distributed is paralysed, and if the cerebrum be destroyed the animal instantly loses all control over its movements. In the living body, therefore, the excitants of the negative sensations are *direct* stimulants to one set of movements, and those of the positive sensations are *indirect* stimulants to another set. Hence arises

the distinction between the voluntary and involuntary motions; the former being those which are controlled by the will, which is a function of the brain, and consequently being dependent on the cerebral system; the latter being independent of the will, because they are excited by the spinal cord, or the ganglion, and being uninfluenced by the brain cannot be subject to the mind.

Irritation, however, of the nervous centres themselves excites the organs which are under their control. The spasms, which sometimes occur in consequence of the pressure of tumours upon the brain and the spinal cord, and the peculiar movements of persons who are labouring under cerebral diseases, in whom the morbid stimulus even overcomes the power of volition, furnish illustrations of this fact.

Although the operations of the brain would cease, as they do during sleep, unless it were constantly aroused by the impressions made on its sensitive nerves by the various external and internal stimuli, yet it must not be imagined that the sensations thus created necessarily act upon the motory nerves, since they very often supply food to the mind without exciting the movement of any organ; while, on the other hand, the brain, impelled by ideas which have at a former period been stored up in the memory, can of itself call into action the voluntary movements. If, for example, I see a blow aimed at my face, I instantly raise my hand to ward it off; in which case the

impression that is conveyed to the brain excites the desire to protect myself, and I do so. But if suddenly remembering that I have an engagement at a distance I go to fulfil it, the impulse which is received by the motory nerve entirely arises from the cerebral influence and the association of ideas.

At the earliest period of life, however, the brain appears to exercise little or no influence over the impression which it receives, for the movements and appetites of an infant are clearly intuitive, and nothing like intellect is manifested until some time after birth, when the organ is perfectly developed, and its functions are invigorated by education.

The experiments of Müller appear to demonstrate that there is no communication between the sensiferous and the motory nerves except at their centres, and consequently that there is no other way by which impressions can be conveyed from the former to the latter. There also seems reason to believe that impressions which are made on the motory nerves *invariably* pass in a direction from the nervous centre to the extremity of the nerve, and never take an opposite course. This may be proved with regard to the cerebral nerves of motion; for if the trunk of one of them be stimulated, contractions are excited in the muscles to which the branches arising below the irritated part are distributed, while the branches which arise above this point are apparently unaffected, inasmuch as no movements of the organs

in which they terminate are thereby produced. The experiments of Müller show, moreover, that if an impression be made upon one or more fibres of a motory nerve, it only affects those parts to which these individual filaments are distributed, and does not influence the other portions of the trunk. "Having," he says, "separated the ischiatic nerve before its division into the tibial and peroneal nerves into several bundles, I irritated each of these singly, and saw different muscles thrown into contraction by the irritation of different nervous fasciculi; thus, according to the fasciculus of the nerve that was irritated, the effect produced was contraction of the muscles of the calf, or extension or flexion of the toes." Thus, each fasciculus of primitive fibres is capable of exerting its motor power independently of the rest of the nerve. This fact is further illustrated by the discovery of Müller*, Kronenberg, and Van Deen, that a spinal nerve entering a plexus, and contributing with other nerves to the formation of a great nervous trunk, does not impart its motor power to the whole trunk, but only to the fibres which form its continuation in the branches of that trunk. On dividing separately each of the nerves which constitute the ischiatic plexus, Van Deen found that, although they were all connected together, yet different muscles were paralysed; and Müller observed, with regard to the three nerves which in the frog compose this plexus, that, by irritating the first of

* Müller's Physiology, translated by Baly.

them, spasms of the muscles of the inner side of the thigh were produced; that irritation of the second excited contractions of the muscles of the thigh and leg; and that when the third was stimulated, motions of the thigh, leg, and foot ensued.

From the decussation of the fibres of the corpora pyramidalia, as well as from numerous pathological observations and experiments on animals, it has been inferred that some of the movements of the body receive their impulse from the opposite side of the brain. If, for instance, the right hemisphere of the cerebrum, or the right side of the cerebellum be injured, the paralysis takes place on the left side, and vice versâ.

This is, however, by no means the case in the spinal cord, for if it be wounded the lesion and paralysis are found on the same side; and in man, even diseases of the brain are very commonly followed by loss of power over the muscles of the same side.

Besides the *voluntary* and *involuntary* motions, there are also certain other movements of the body, which, though controllable by the will, are nevertheless most commonly exercised involuntarily; and these therefore may be called *semivoluntary* motions.

CHAPTER XII.

OF THE INVOLUNTARY MOTIONS.

The involuntary movements may be divided into two classes: 1st, Those of the muscular organs; such as the heart, the stomach, the intestines: 2d, Those of the secretory and absorbent organs; such as the capillary vessels of the membranes, the glands, &c.

For the first explanation of the connexion between the involuntary motions and the nervous influence, we are indebted to a paper "On the Use of the Ganglions of the Nerves," by James Johnstone, M.D., of Worcester, which was inserted in the Philosophical Transactions of the year 1764, and to an Essay on the same subject, which was published by Dr. Johnstone in 1771. The object of these works was to prove that the involuntary motions are dependent upon the ganglionic nerves, and are neither produced by the spontaneous contraction of the muscular fibre, nor by the spinal and cerebral systems.

In pursuing his enquiries, he found that when the heart beat only forty in a minute, if the spinal cord were irritated with the point of a probe, the limbs were immediately convulsed, while the heart

was not in the least affected. This experiment was made on frogs as well as on six kittens, their heads having been previously cut off between the first and second vertebræ. In all the trials which he made, by thrusting the probe into the spinal marrow, the motion of the heart and intestines remained unaffected; though in one case, violent convulsions of the limbs and opisthotonos, together with contraction of the diaphragm, followed the operation. The experiments of Haller and Whytt produced similar results; and one, which is related by the latter physiologist, most remarkably confirms Dr. Johnstone's views respecting the ganglia.* Some young gentlemen having hanged a cat till she was quite dead, opened the thorax, and observed only a tremulous motion in the heart, which soon ceased, but was renewed by pricking it with a sharp instrument: after this, by squeezing the cardiac nerves downwards, or otherwise irritating them, the heart was made to perform two or three pulsations, which it continued to do for a considerable time, whenever the cardiac nerves were thus stimulated. Can these phenomena be better explained than by the supposition that when the heart was pricked, the impression was conveyed by the cardiac nerves to the cardiac ganglion, which when thus irritated, called into action the organ itself through the medium of its motory nerves; and

* Essay on the Vital and Involuntary Motions of Animals. By R. Whytt, M.D., p. 355.

that when the nerves were squeezed, the impression passed directly to the heart?

These are not isolated facts, for we are told by Müller that Humboldt has excited contractions of the heart in mammalia by the application of galvanism to the cardiac nerves.

From Johnstone's numerous experiments and pathological observations, an account of which may be found in the second edition of the Essay on the Ganglions, he infers that ganglions are the sources or immediate origins of the nerves, sent to organs moved involuntarily; and probably the check or cause which hinders our volitions from extending to them. Ganglions seem analogous to the brain in their office; subordinate springs and reservoirs of nervous power, they seem capable of dispensing it long after all communication with the brain is cut off. And though they ultimately depend upon the brain for its emanations, it appears from facts that that dependence is far from being immediate and instantaneous. From the ganglions serving as subordinate brains, it is that the vital organs derive their nervous power, and continue to move during sleep; and to the same cause, as well as to its greater irritability, we may refer the continuance of the motion of the heart so much longer than that of the voluntary muscles in perfect apoplexies. Thence, too, the motions of the heart receive for some time support, even after the spinal marrow and the intercostals in their descent along the neck are cut through; so that animals survive this ex-

periment sometimes thirty hours, which, however, proves at length certainly fatal, by cutting off all communication with the prime fountain of nervous emanation.

"In a word, ganglions limit the exercise of the soul's authority in the animal economy; and put it out of our power by a single volition to stop the motions of our heart, and in one capricious instant irrevocably to end our lives."

It appears then that Dr. Johnstone regarded the ganglia as *subordinate brains*, or, in other words, as nervous centres distinct from though connected with the cerebral system; and the experiments which he has adduced in great measure corroborate his hypothesis. He proved that the ganglionic system is not amenable to the will, and that the organs which are under its control move involuntarily; but the state of physiological science at the period when he lived did not afford any very clear insight into the causes of the phenomena which he discovered. The more recent discoveries, by Sir Charles Bell, of distinct sets of sensitive and motory cerebral nerves, and of the spinal system by Dr. M. Hall, seem, however, to point out an analogy, which in the dearth of conclusive experiments might be admitted as a reasonable explanation of the relation between the ganglionic nerves and the involuntary motion.

From such data it might be conjectured that each ganglion, like the other nervous centres, is provided with sensitive and motory filaments; and we

are not entirely destitute of experimental evidence in proof of this theory. By applying galvanism to that portion of a divided splanchnic nerve (in a rabbit), which was connected with the cœliac ganglion, the nerve lying on a plate of glass, Müller succeeded in causing increased peristaltic action of the whole intestinal canal; and in another instance, he restored vigour to the peristaltic movements, when they had almost ceased, by touching the cœliac ganglion with caustic potash.

The heart of a cat which had been dead for four hours was excited into alternate contractions, by blowing warm air into its cavities through a tube fixed in the *receptaculum chyli*.*

The motion of the heart was renewed in the same manner by Brunnerus, in a dog which had been some time dead.

In the latter two instances the air, on entering the cavities of the heart, must doubtless have stimulated the cardiac nerves of sensation and their ganglion, which would excite the cardiac nerves of motion to act upon the muscular part of the heart; as in another case which I have already mentioned.

Such, probably, is the manner in which the stimuli that create the negative sensations of ganglionic nerves produce action in the muscular organs; thus exciting the peristaltic motion of the intestines, the contractions of the heart, and other involuntary movements. These stimuli are, as I

* Whytt's Essay on the Vital and Involuntary Motions, p. 356.

have already stated, in the alimentary canal, the food, the bile, and the gastric and intestinal juices; in the heart and arteries, the red blood; and in other parts, animal heat, the secretions, &c.; so that, to use the words of Dr. Johnstone, "In the involuntary motions, the stimulus which excites, regulates their intenseness and continuance."

It has been urged, however, by the advocates of innate muscular contractility, that the heart of the turtle and of some other animals continues to contract for several minutes and even hours after the head has been struck off and the circulation has ceased; but the reason of this seems to be that the ganglionic nerves, though less excitable than those of the spinal and cerebral systems, retain their irritability much longer, and even support the action of the organs which they supply some time after their stimuli have been withdrawn. The peculiarity of their structure may perhaps account both for this circumstance and for the singularity of the movements which they excite; the muscular motions controlled by them being tremulous and vermicular, and less violent and convulsive than those which are regulated by the spinal cord and the brain.

The explanation that has been given of the mode in which the nervous power is communicated to the involuntary muscles is also in a great measure applicable to the influence of the nerves on the secretory and absorbent organs. In speaking of the ganglia, Johnstone says, "May they not be

supposed to have some use in glandular secretion? For we see the glandular parts in the abdomen are supplied by the great sympathetic nerves, as well as the muscular fibres of the heart and intestines." These views have been adopted by Mr. Clark* and Mr. Grainger;† the latter of whom was induced to form this opinion from the anatomy of the ganglionic system; from the existence of the great sympathetic in all its integrity, in cases of deficiency of the cerebro-spinal axis; from the early appearance of the sympathetic ganglia in the embryo, from their superior development when contrasted with the cerebro-spinal system in the fœtus, and at the earlier periods of life, when nutrition is in its most active state; and lastly, from the circumstance that the contraction of all those organs to which the sympathetic is distributed, with the questionable exception of the kidneys, is incessantly being influenced by physical agents. As an illustration of this principle, Mr. Grainger supposes that the flow of saliva is excited by the transmission of the impression made by the food on the nerves of the tongue to the submaxillary ganglion, and thence to the salivary ducts, though, owing to the connexion with the cerebral nerves, this secretion is somewhat influenced by the mental emotions, such as those which arise from the sight of food.

* The Practical Anatomy and Elementary Physiology of the Nervous System.

† On the Spinal Cord.

That the secretory and absorbent organs are under the control of the nervous system is indeed evident from the alterations which take place in the animal fluids, in various nervous disorders. Thus, hysteria is frequently attended by a large secretion of pale urine, as well as by morbid changes of the menstrual discharge; injuries of the spinal cord are often followed by secretion of the earthy phosphates by the mucous membrane of the bladder and the kidneys; and the agency of the mental emotions in exciting jaundice, indigestion, and other maladies, must be ascribed to the nervous system.

The experiments on this subject are also highly worthy of consideration.* Krimen found that, on dividing the sympathetic nerve in the neck, the urine becomes alkaline and albuminous, but the application of galvanism restores its natural properties; and Brachet observed that bloody urine resulted from division of the renal nerves. Müller and Peipers entirely stopped the secretion of urine, by destroying the texture of the renal nerves, in a series of experiments on dogs and sheep, among which only one exception occurred, and then the urine was bloody, and contained hippuric acid.

Numerous experiments have likewise been instituted respecting the influence of the pneumogastric nerves on the secretion of gastric juice; but the inferences which have been drawn from them differ so much, that it is not so easy to form an opinion

* Müller's Physiology.

on this subject. Leuret and Lassaigne could perceive no effect from the operation, except paralysis of the sphincter of the pylorus; while from their own investigations, as well as those of Baglivi, Valsalva, Haller, Legallois, Philip, Breschet, Vavaseur, Edwards and others, Tiedemann and Gmelin arrived at the following conclusions:

1st. Simple division of the pneumogastric without excision of a piece of it, or without any change in the respective direction of the two ends, does not stop the digestion, but merely slackens it.

2d. Division of the nerve, together with the loss of part of its substance, considerably diminishes the power of digestion, much more so than the mere division of the nerve, but it does not entirely stop it.

3d. The division or destruction of a portion of the spinal marrow, or the excision of a part of the brain, exercises a similar influence upon digestion.

4th. Narcotics, given in a sufficient dose to produce sleep, weaken the action of digestion.

5th. When digestion is almost suspended after the division or excision of the pneumogastric nerve, it may be restored by means of electricity or galvanism applied to the stomach. The restoration of the digestive power by means of electricity, does not arise from its chemical action on the food, but from the movement of the muscular coat of the stomach being excited by the electric influence, and being thereby brought into contact with the alimentary substances contained in that viscus.

6th. The principal part which the par vagum

plays in the digestive action, consists in exciting those movements of the stomach which contribute to the fulfilment of its functions, and increase the contact of the gastric juice with the food.

7th. The slackening of the digestion after the division of the pneumogastric nerve proceeds from paralysis of the muscular coat of the stomach.

It would therefore appear that the pneumogastric nerves *assist* in regulating the movements of the stomach, but possess little or no influence over the secretions. The experiments of Magendie also prove the same fact; for he found that food was digested and converted into chyme, which afforded abundance of chyle, after the pneumogastric nerves had been divided; whereas, if the motions of the stomach were *entirely* dependent on these nerves, division of them would cause the contractions of the organ to cease, and the chyme would not pass, as it really does, into the intestines. We must therefore conclude that the involuntary movements of the stomach, and the secretion of the gastric juice are principally regulated by the ganglionic nerves, which, nevertheless, are aided in the former part of their office by the par vagum. It is indeed well known that most of the vital organs receive filaments both from the spinal and from the cerebral nerves: the former of which, like every portion of the nervous system, doubtless contribute to preserve harmony of action between parts which are distant from each other, while the latter render them more or less subservient to the influence of the mind;

but in the viscera, of which the motions are purely involuntary, we find the greatest proportion of ganglionic nerves.

It is strange that pathology should have hitherto failed to throw much light upon the influence of the ganglionic system over the involuntary motions.* Lobstein, however, observed deep redness of the semilunar ganglia, without lesion of any other organ, in two females who had suffered from uncontrollable vomiting, and both Aronssohn and Andral found the same appearances in persons who had been affected with tetanus. Dr. Duncan discovered great enlargement of the sympathetic nerve in a case of diabetes; and I witnessed the dissection of a man who had died of spasmodic cholera, in whom the semilunar ganglia were vastly enlarged. These facts, though not alone sufficient to demonstrate the office of the ganglionic system, seem to corroborate the experimental evidence.

Whatever may be the functions of the sympathetic nerves, there are certainly some involuntary acts which appear to be exclusively regulated by the spinal system. Such are, 1st. Vomiting, which is caused by an anti-peristaltic motion of the stomach, accompanied with violent contractions of the abdominal muscles and diaphragm. It may be excited by irritation of the pharynx, œsophagus, stomach, intestines, or of almost any other part of the body; and the impression being communicated

* See Andral's Anatomie Pathologique, where several other instances are recorded.

by the sensiferous nerves to the spinal cord, the pneumogastric and phrenic nerves are called into action, and excite the muscles which effect the operation, unless irritability of the brain be the exciting cause; for then the impression is, in all probability, transmitted directly along the cerebral filaments of these nerves.* 2dly. Sneezing, which is caused by expanding the chest, and then rapidly expelling the air, arises from irritating impressions on the Schneiderian membrane, which being propagated along the trifacial nerve stimulate the spinal cord; whereby the nerves and muscles of respiration are excited. 3dly. Hiccuping, which consists in a quick convulsive contraction of the diaphragm, and is either the consequence of irritation of the stomach, or is symptomatic of disorder of the nervous system. 4thly. The emission of semen, performed by the ejaculatores urinæ, which are supplied with nerves from the sciatic plexus, and, *perhaps*, the uterine contractions, though this is by no means proved.

The secretion of milk seems also to be controlled by the spinal system, for the mammary gland receives branches from both the phrenic and the intercostal nerves, but none from the sympathetic nerve have been as yet traced to it. Dr. M. Hall, moreover, attributes the *tone* of all the muscles to the agency of the spinal system, because he found that if the spinal cord be destroyed the

* In Lobstein's cases just referred to, the lesion of the ganglion probably caused vomiting by its influence upon the gastric juice, not by its action upon the muscles of the stomach.

limbs of the animal become relaxed. Hence we see a satisfactory explanation of the tonic effect of cold, when applied to the surface of the body; but Dr. Hall's observations have reference to the external parts only; and it may be a question, whether the tone of the internal muscular organs be not dependent on the ganglionic system.

The following experiments seem further to display the influence of the spinal system over the involuntary motions and secretions.

The secretion of mucus in the bronchial tubes undergoes a marked change when the pneumogastric nerve is divided, speedily becoming frothy and bloody; and Magendie observed that the injection of emetics into the veins causes less inflammation of the stomach and lungs, if this nerve be cut through, than while it is entire. If the trifacial nerve be divided, it is impossible to excite inflammation of the eye by artificial means; though in the course of a few days after the operation, it spontaneously takes place; probably in consequence of local congestion, which so commonly follows diminution of activity or vitality. The same circumstance has been noticed when the sympathetic nerve has been tied, as well as after removal of its superior cervical ganglion; and Magendie has observed that after division of the trifacial nerve the cornea becomes opaque and ulcerates. While attributing involuntary acts either to spinal or to cerebral nerves, it must be remembered that, according to

Müller, they all receive gray fibres from the ganglia; so that, after all, the functions and phenomena of which I have just been speaking may perhaps depend upon ganglionic influence.

The great difference in susceptibility of inflammation between parts which are receiving their natural supply of nervous power and those which are paralysed would lead to the conclusion that the nerves exercise considerable influence over the capillary circulation, though it is uncertain whether this office be confined to the ganglionic nerves, or whether it be common to all parts of the nervous system; while from the powerful control of the nerves over the organs of digestion, circulation, and secretion, it necessarily follows that the growth and nutrition of the body are in a great degree regulated by them.

Hence, we often find that paralysed limbs after the lapse of a few weeks lose their former bulk; their temperature is also in some cases much lower than that of the rest of the body; and if injured, they are particularly liable to gangrene. Since indeed the circulation and respiration are so dependent upon the nervous system, animal heat must likewise be influenced by it; though perhaps, as Abercrombie suggests, the alteration of temperature in paralytic limbs may be partly attributed to their having lost that power of resisting the atmospheric influence, which is so remarkable a property of living bodies, for they are certainly

more affected by the heat to which they may be exposed, than are healthy parts under similar circumstances.

Besides the organs which I have already mentioned, the ganglionic nerves preside over the apparatus for secreting the seminal fluid of the male, and over the ovaries of the female; so that they are alike essential to the nourishment of the individual and to the perpetuation of the species. The menstrual secretion is also probably under their regulation; but they are so interwoven with the branches of the spinal nerves, that this point is as yet undetermined.

Although, as their appellation implies, the involuntary motions can neither be stopped nor hindered by any effort of the will, yet they are singularly affected by the passions, being modified by all the more powerful emotions of the mind. The agitation of the whole frame, and more especially palpitation of the heart, the irritation of the sexual organs, and the derangement of the digestion and of the secretions, which occur in consequence of joy, sorrow, anxiety, or desire, sufficiently illustrate the fact, and represent a class of involuntary actions which are controlled by the brain. This subject I shall again notice in treating of Sympathy.

CHAPTER XIII.

OF THE SEMIVOLUNTARY MOTIONS.

In speaking of the spinal (or, as he calls it, the *excito-motory*,) system, Dr. M. Hall observes that "there is always the application of an appropriate stimulus or cause of excitement or irritation; this is followed by the contraction of peculiar sets of muscles. It is clearly proved that the influence of the stimulus is carried along an excitor and incident (in other words a sensitive) nerve, to the medulla oblongata or medulla spinalis, and that it is reflected thence along other reflex or motor nerves. The incident excitor nerves, the medulla, and the reflex motor nerves, constitute the system. They remain after the centre of the cerebral system has been removed by experiment, or destroyed by discase. Their distribution takes place principally about the larynx and pharynx, in connexion with the medulla oblongata, and about the sphincters, in connexion with the lower part of the spinal marrow; and hence they especially guard the orifices and exits of the animal frame. Other parts of the system govern the acts of ingestion, deglutition, and respiration; and the acts of excretion of the

fæces, urine, and semen. A third portion of the system gives general tone to the muscular system, and consequently to the limbs."*

The functions which Dr. Hall here states to be under the direction of the spinal system include most of the semivoluntary motions; besides the emission of semen and the tonicity of the muscles, both of which are purely *involuntary*. The movements which are excited by the spinal cord *alone* must be involuntary; but the trunks of the motory spinal nerves, like the sensiferous nerves of that system, are usually bound up with fibres of the cerebral system, so that on emerging from its centre each fasciculus contains one set of filaments, which is controlled by the will, and another which is independent of it. The consequence of this arrangement is that the movements of the organs, to which these mixed nerves are distributed, are partly voluntary and partly involuntary; that is, *semivoluntary*. The few instances in which *involuntary* acts are regulated by spinal nerves may be explained by the supposition, that in such cases the organ receives branches which contain spinal filaments only. The motory nerves of the spinal system are the motores oculorum, the lesser portions of the trifacial, the abducentes, the facial, the glossopharyngeal, the pneumogastric, the spinal accessory, the sublingual, the anterior roots of the spinal nerves; and, *perhaps*, the pathetic.

* Lectures on the Nervous System. See also Müller's Physiology.

I shall now notice in detail the most remarkable of the semivoluntary movements.

1st. *Deglutition.* The food, being introduced into the mouth and masticated, is in the first place pushed backward by the pressure of the tongue and palate till it reaches the pharynx; the velum palati or soft palate becoming at the same time tense, and being also raised so as to close the communication between the mouth and the nostrils. The root of the tongue and the larynx being then elevated and drawn forward, the epiglottis falls upon the fissure of the glottis, and the mass being impelled by the contraction of the constrictors of the pharynx and velum palati glides into the œsophagus. Lastly, the food is carried on by contractions proceeding from the upper to the lower part of the œsophagus, until it arrives in the stomach.

In this process, the first step is voluntary, and the last involuntary; while the movements of the pharynx, the root of the tongue, the larynx, epiglottis, and soft palate which constitute the second stage, are semivoluntary. The stimulant action of the food upon the sensitive branches of the pneumogastric and glossopharyngeal, and, as Reid thinks, of the trifacial nerves, excites the medulla oblongata, which stimulates the muscles of deglutition through the medium of the motory filaments of the glossopharyngeal and pneumogastric nerves.

Deglutition is in like manner induced by the stimulus of the saliva; but in every case it may be

either suspended or promoted by the will, provided the nerves be under the influence of an excitant in the throat.

2d. *Evacuation.* The expulsion of fæces and urine are obviously dependent upon the spinal nerves; for injury of the spinal cord is constantly succeeded by paralysis of the sphincters, and difficulty in expelling these excrements. In their ordinary state the sphincters are contracted; but when the excretions accumulate, the irritation which they occasion in the rectum and bladder stimulates the spinal cord, whose motory nerves being called into action excite contractions in the muscular coats of these organs; the sphincters are relaxed, and the urine, or fœcal matter is emitted. We can, however, either procrastinate these operations; or by simultaneously contracting the diaphragm and abdominal muscles, so as to diminish the cavity of the abdomen and compress the bladder, intestines, and other viscera, promote their evacuation.

3d. *Respiration.* For our knowledge of the nerves of respiration we are indebted to Sir C. Bell; who, among other brilliant discoveries, first pointed out that part of the nervous system which excites and controls the respiratory movements. He showed that the mechanism of respiration is not confined to the mere expansion and contraction of the chest; but that it is also necessarily accompanied by a corresponding action of other parts;

such as distension of the nostrils during inspiration, movement of the uvula, &c.

He further discovered that all these organs are supplied with nerves, which arise from the medulla oblongata, and are not entirely subservient to the will; and thence he inferred that they might be regarded as forming a distinct portion of the nervous system, to which he gave the appellation of the *respiratory nerves.*

From these observations and numerous experiments, Sir C. Bell drew the conclusion that in the lateral portion of the medulla oblongata, from which the several respiratory nerves go off, there is seated a power which, passing out through these diverging nerves, combines the remote organs; and that the regular succession of actions in respiration is directly consequent upon the influence of this part of the nervous system.*

The facts which are detailed by this great discoverer do not admit of a doubt; but I am inclined to think that Dr. M. Hall has given a more correct explanation of them. He agrees with Sir C. Bell in the opinion that the respiratory is entirely distinct from the other subdivisions of the nervous system; but he differs from Sir Charles, inasmuch as he views the respiratory as but a part of a more extensive system; as an excited and not a spontaneous function; as *originating*, when the cerebrum is removed, in the pneumogastric nerve as its

* Bell on the Nerves, 3d edition, p. 119.

excitor, and not in the medulla oblongata: while, according to Müller, the cause of the excitement and of the continued action of the medulla oblongata, in determining the respiratory muscles to action is the arterial blood.

If both the pneumogastric nerves be divided in the neck, the respiration becomes laborious, and the animal never survives the operation more than three or four days; but usually dies in a much shorter period. Death may, however, immediately ensue in consequence of the paralysis of the muscles of the glottis, which is caused by division of the recurrent and other laryngeal branches of these nerves; but in other cases the operation seems merely to destroy the negative sensibility and contractility of the air-tubes; so that respiration may for a time be supported by the medulla oblongata, stimulated by the arterial blood, and by voluntary movements of the intercostals and diaphragm.

In respiration, the air is first drawn into the lungs, or *inspired;* and secondly it is expelled from the lungs, or *expired.*

During inspiration, the cavity of the chest is enlarged by the contraction of the diaphragm, of the intercostals, and of some of the thoracic muscles, the nostrils, glottis, and bronchial tubes being at the same time dilated. When the air is admitted through the nose, the passage to the mouth is closed by pressure of the tongue against the palate; and when it is received through the mouth, the soft palate is elevated.

Expiration spontaneously follows inspiration. It requires no effort, and is accomplished by the relaxation of the parts which are actively employed in inspiration. In respiration, a portion of the oxygen and nitrogen which compose atmospheric air is absorbed, and carbonic acid is exhaled.

The respiratory apparatus is set in motion, according to Dr. M. Hall, by the stimulus of the carbonic acid acting upon the spinal nerves, and more especially upon the pneumogastric nerve, by which the impression is conveyed to the medulla oblongata, whence it passes back along the pneumogastric, phrenic, and other spinal motory nerves to the diaphragm, bronchiæ, intercostals, &c.

The first inspiration is probably caused by the action of the air upon the trifacial nerve in the nostrils and on the face, and the sympathetic irritation which would necessarily be excited in the diaphragm and lungs through the pneumogastric and phrenic nerves, as in sneezing.

Sir C. Bell enumerates as respiratory nerves the par vagum,* portio dura, glossopharyngeal, spinal

* Mr. Langston Parker regards the par vagum as the sole chemical agent of respiration. "It is through the medium of this nerve," he says, "that the blood is deprived of carbon, and by which oxygen is substituted for it." (See an excellent course of Lectures on Comparative Anatomy in the Medical Gazette, 1830.)

M. Arnold concludes from various experiments, that the pneumogastric is a purely sensitive nerve, communicating the sensations of hunger and the want of breathing, and having no direct influence either upon the secretions, or upon the organs of motion.

(Provincial Medical and Surgical Journal, vol. i. No. ii.)

accessory, phrenic, and the external respiratory nerves; all of which are moreover instrumental in the performance of the following mechanical actions, connected with respiration.

α. *Coughing* consists in a spasmodic contraction of the muscles of respiration, and is produced by irritation in the air-passages, which being communicated by the pneumogastric nerves to the medulla oblongata, that nervous centre is excited, and stimulates the intercostals, diaphragm, &c.

β. *Sighing* is nothing more than a full, slow inspiration and expiration. It is caused by the uneasiness which an accumulation of black blood in the lungs always occasions, and it appears to relieve this state by exciting the pulmonary circulation.

γ. *Yawning* is the consequence of debilitated nervous action, which of course affects the pulmonary circulation, as well as other parts of the body. It consists of a slow deep inspiration and expiration, accompanied with opening of the mouth. It differs from sighing, inasmuch as, in addition to the movements of the chest, the respiratory muscles of the face, which are under the control of the portio dura, are also called into action.

δ. *Laughing* is the result of an inspiration followed by a succession of short quick expirations,

and may arise either from mental emotions or from bodily irritability.

ε. *Sobbing* is a succession of spasmodic inspirations followed by an expiration; and is occasioned either by sorrow, or, like laughing, by corporeal affections.

4th. The physiognomical expressions of the countenance, and the various attitudes of the body, indicating either physical or mental pleasure or pain, may also be numbered among the semivoluntary motions. When they are excited by physical causes, the muscles are called into action by means of the spinal system; but if they arise from emotions of the mind, we may presume that the impression is propagated from the brain, through the cerebral filaments which accompany those of the spinal nerves. Hence the contortions of the frame and the anxiety of countenance which are so frequently observed in painful diseases; the peculiar expressions which denote the passions, and those which are attendant on the respiratory movements, such as laughing, sobbing, &c.; and hence also the power which is possessed by man of commanding by his eye and his gestures animals which are vastly superior to him in strength.

The expression of countenance which the experiments of Sir C. Bell prove to be regulated by the portio dura may be assumed at pleasure; but it is worthy of remark that the mind also exercises

over the semivoluntary motions a sympathetic influence, which is quite distinct from volition. Thus, for example, a fit of laughter excited by some droll occurrence often continues, to the great annoyance of the individual, at a time when he is most anxious to restrain it, and exerts all his power to do so.

In this case, the impression arises in the brain, and the convulsions of the muscles are the result of the mental stimulus; nevertheless it is an involuntary act. Indeed, many parts of the body, which are in no degree subject to the will, are easily affected by the other passions.

CHAPTER XIV.

OF THE VOLUNTARY MOTIONS.

I HAVE already said that voluntary motions are dependent on the cerebral nerves, and are excited by the will, which, together with the other mental faculties, has its seat in the cerebral hemispheres of the brain.* It has also been stated† that the cerebellum is supposed to assist in *regulating the muscular movements,* and from the experiments of Magendie, it would seem probable that the corpora striata aid the performance of the voluntary motions, as indeed they must do, since the motory fibres of the cerebrum pass through them on their way to the anterior column of the spinal cord.

Magendie has also instituted experiments on the pons varolii and pyramidal bodies, whence he infers that there exist in the mammalia several different forces or impulses by which the animal is impelled forwards, backwards, &c.; but I perfectly agree with Mr. Mayo, that the whole of the phenomena in these cases may be attributed to a sensation analogous to vertigo, and consequently prove nothing.

* See Chapter on the General Laws of the Animal Motions.

† See Chapter on Positive Sensation.

From the brain the stimulus of the will is conveyed to the various organs of voluntary motion, by the 3d, the 4th, the smaller portion of the 5th, the 6th, the 7th, the 10th, and the 11th cerebral nerves, and by the filaments from the anterior roots of the spinal nerves. In effecting any particular movement, the act of volition creates an impression on one or more of these nerves, which is transmitted by them to the muscles. The desire to excite the action is the result of the mental operations; but the power of guiding our motions can only be acquired by experience, and is in great measure directed by the sensations. This is the reason why children are unable to use either the hands, the legs, or the larynx, until they have had time to obtain a certain range of ideas by means of the senses, and until by frequent repetition of the same effort, they find that it is invariably succeeded by the same movement.

Having spoken of the indirect influence of the sensations, more especially of sight, feeling, hearing, and the muscular sense, on the voluntary motions, when we were engaged in the consideration of those subjects, it is unnecessary in this place to repeat the remarks which I then made; but I have yet to say a few words on the *association* which subsists between the movements of certain organs. The phenomena to which I allude are far from uncommon, and numerous examples might be adduced; but a few will suffice for illustration, as the

same principle is applicable to all of them. Thus, if the iris of one eye be either contracted or dilated, its fellow is similarly affected : if one eyeball be directed to an object, the other undergoes a like movement: if the eye be turned upward or inward, the pupil contracts : and it is exceedingly difficult to move the arm and leg of the same side in different directions. These, as well as all the other *associated* voluntary movements, are the result of our want of practice in separately exercising them; so that the cerebral impression simultaneously affects whole bundles of nervous fibres, instead of stimulating those only which we wish to call into action. "The primitive fibres of the voluntary nerves," says Müller, "being at their central extremity spread out in the brain to receive the influence of the will, we may compare them as they lie side by side in the organ of the mind to the keys of a piano, on which our thoughts play or strike, and thus give rise to currents or vibrations of the nervous principle in a certain number of primitive nervous fibres, and consequently to motions. From the conducting power of the cerebral substance at the origin of the nervous fibres, however, those which are contiguous to each other must be liable to be affected simultaneously, and the influence of volition will be with difficulty confined to single fibres." Nevertheless, experience which teaches the infant to use its limbs, its voice, and its eyes, enables the adult to command all the volun-

tary organs; and to agitate the stream of nervous fluid in its minutest channels, without disturbing the adjoining portions of it. By practice, each fibre at length becomes as independent of those around it, as if it were a distinct nerve, and the parts to which it is distributed obey the will without displaying their wonted associations. Hence, sportsmen acquire the power of opening one eye, while the other remains closed; and jugglers are enabled to exhibit the most extraordinary contortions of the body.

The muscles with their tendons are the instruments in all the voluntary motions, and the contraction of their fibres is induced by the stimulus which they receive from the nervous matter, excited by the act of volition. Muscular contraction may also be excited by the application of various stimuli; but I can see no sufficient reason for supposing that muscles ever spontaneously contract or can do so, unless the irritability be called forth either by a nervous or by an electric current.

The bones and cartilages also perform an important part in voluntary motion, by affording firm surfaces for the attachment of the muscles; by supporting the animal frame; and, with the assistance of the ligaments which unite them, by serving the double purpose of levers and of fulcra.

To illustrate the phenomena of voluntary motion, I shall mention a few of the most striking examples; but it will be unnecessary to examine in detail every movement of this class.

1st. *Sucking*, which is the mode whereby all young animals of the mammalia obtain nourishment, consists in applying the lips close to the nipple or to the vessel which contains the food, and then exhausting the mouth of air, so that the fluid may flow into the vacuum. This is effected by means of the tongue, together with the muscles of the cheeks and lips, which are called into action by the portio dura and the hypoglossal nerve, the respiration being at the same time carried on without interruption through the nostrils. I speak of sucking in this place, because in the adult it is always a voluntary act; nevertheless, at the earliest period of infancy, it seems to be purely instinctive; being probably excited either by irritation of the lips themselves, or by uneasy sensations in the stomach; the first of which impressions are transmitted by the trifacial, and the second by the pneumogastric nerves to the medulla oblongata; which, like the brain, acts upon the muscles of the mouth, through the medium of the portio dura and the hypoglossal nerve.

2d. *The Voice.** The apparatus of the voice is composed of the lungs, by which air is alternately drawn into and expelled from the chest; the trachea through which the air passes; and the larynx by which it is modulated. The lungs and trachea merely act as a pair of bellows with its pipe, but

* A very full and excellent account of the voice is given by Mr. Mayo, in his Physiology.

the function of the larynx is much more complicated. It is formed of several cartilages, connected together by ligaments, lined with a mucous membrane, and moved by numerous small muscles. The lowest of these cartilages, which is called the *cricoid cartilage,* is situated immediately above the rings of the trachea; upon the posterior part of the superior surface of the cricoid cartilage are placed the two arytenoid cartilages, and all the three are embraced anteriorly and laterally by the thyroid cartilage. The vocal ligaments or cords are extended between the thyroid and arytenoid cartilages, so as to leave between them an aperture which is termed the glottis. Attached to the thyroid is the fibro-cartilaginous body which is known by the name of the epiglottis.

The organs of the voice are supplied with filaments from the pneumogastric nerves and from the superior cervical ganglia.

The larynx is in fact a pipe, at the mouth of which are two fibrous membranes with vibrating edges, namely, the vocal ligaments, so that the air which passes from the lungs, coming in contact with them, excites vibrations in the ligaments, and thus produces the voice; much in the same manner as the wind rushing through a crevice in the window puts in motion the strings of the Eolian harp. It has been shown by Professor Willis, of Cambridge, that unless the edges of these ligaments be parallel to each other there can be no vibration, and therefore no sound; and he is of opinion that the

modulation of the vocal notes is mainly regulated by the crico-thyroidei muscles, which stretch the vocal ligaments, and place them in the vocalizing position; while the aperture of the glottis is opened by the crico-arytenoidei postici, and closed by the crico-arytenoidei laterales, which bring together the anterior portions of the arytenoid cartilages; and the arytenoideus transversus, and arytenoidei obliqui, which draw together their posterior portions.*

The attachment of these muscles and the direction of their fibres would, however, lead to the inference, that the crico-arytenoidei postici draw back the arytenoid cartilages, and thus tighten the vocal cords; that the thyro-arytenoidei draw the arytenoid cartilages forward, and relax the cords; that the glottis is opened by the crico-arytenoidei laterales which separate the arytenoid cartilages; and that the glottis is closed by the arytenoideus transversus, and the arytenoidei obliqui, which bring the arytenoid cartilages into contact with each other.†

If the pneumogastric nerves or their recurrent branches be divided, these muscles are paralysed, and the voice is enfeebled or destroyed. As the trachea and larynx, by confining the air within a narrow compass, increase the intensity of the vocal sounds, the tone of the voice must in some measure

* Cambridge Philosophical Transactions, and Mayo's Physiology.

† This hypothesis is advocated by Mr. Sands Cox, and other eminent anatomists.

be influenced by the caliber of these tubes; and hence the voices of women, children, and eunuchs, in all of whom the larynx is smaller, and the vocal cords are shorter than in men, are pitched in a comparatively high key.

Elevation of the larynx also conduces to raise the tone, and depression of it produces a contrary effect; while the voice is further modified by the movements of the mouth, tongue, and lips. The elasticity of the trachea moreover contributes to increase the variety of sounds, by rendering it susceptible of different degrees of tension, and the nasal cavities give depth to them; but the special office of each portion of the vocal apparatus still requires investigation.

From a certain age the voice is entirely governed by the will, and is excited by the cerebral influence; but it is probable that immediately after birth, vocal sounds may be produced through the agency of the spinal cord, in consequence of organic impressions, and without the intervention of intellect.

The voice is possessed by all the higher classes of animals, and is the means by which they express their feelings, and make known their wants. The instinctive desires and passions of the brute creation, are recognized by their cry, and the same mode is naturally adopted by the human infant, to proclaim its hunger or its sufferings. Joy, sorrow, fear, and the other passions, have each their peculiar cry; which indeed is the only method whereby animals can communicate with one another.

3d. *Speech.* Man, however, whose mind comprehending a larger store of ideas requires some more definite means of expression, and whose position in the world as a social being renders him peculiarly dependent upon his fellow-creatures, is moreover endowed with the faculty of speech.

Articulate sounds are the result of modifications, which the voice undergoes in its passage through the mouth. Thus, of the sounds of letters, the vowels are pronounced by placing the lips and tongue in such positions, as to diminish the width of the fauces without offering any obstacle to the transmission of the air; the difference between them, being caused by the greater or lesser contraction of the cavity; whereas, in the pronunciation of consonants, the air is interrupted in its transit through the mouth. We usually speak during the act of expiration; but we are likewise able to do so during inspiration, in which case, instead of the air from the lungs, that of the atmosphere, which is drawn into the mouth, is subjected to the necessary modifications.

The power of modulating the voice, so as to produce musical notes, which constitutes singing, appears to depend upon the movements of the larynx and trachea, more than upon the motions of the tongue and lips.

Speech is the quickest and easiest mode of communicating our ideas to the rest of mankind; and is one of the principal faculties by which we either

command or conciliate animals of a lower grade than ourselves.

The acts both of speaking and of singing are entirely voluntary ; and are, as I have already stated, so much guided by the sense of hearing, that persons born deaf are necessarily dumb. This is one of the great distinctions between the exercise of speech and of the voice; for while the latter is possessed by idiots, by children even at the earliest age, and by the deaf, the former is exclusively the property of those who can hear and think. If the vocal organs be perfect in such individuals, as they usually are, the *cry* may be produced by any irritation of the nerves, which may bring the muscles of the glottis into certain positions, but they can only be made to articulate by the aid of reason and the ear.

4th. *Locomotion.** *Walking,* which consists of a succession of steps ; *leaping,* which is produced by first bending the legs, and then suddenly extending them ; *running*, in which the fore part of each foot is alternately placed on the ground, the limb being then contracted, afterwards extended, and lastly thrown forward, while its fellow is going, through a similar set of movements ; and *swimming*, which, as regards the human race, is performed by simultaneously striking the water with the arms and legs ; are under ordinary circumstances controlled by the will : but if the influence of the brain be de-

* On this subject see Magendie's Physiology.

stroyed by disease, or if the cerebrum be removed by operation, these motions may become involuntary.

5th. The foregoing remarks are also applicable to several movements of the trunk and limbs, which it is unnecessary to enumerate; as well as to the motions of the hand, the beautiful mechanism of which gives to man a degree of physical power, quite disproportioned to the delicacy of his frame, when compared with the larger and more hardy animals.

6th. Lastly, the postures of sitting, kneeling, and standing are maintained by an act of the will; for if a person fall asleep while in any of these attitudes, he drops down into the recumbent posture, unless held up by some artificial support.

CHAPTER XV.

OF SYMPATHY.

I. The term sympathy is commonly employed to denote a peculiar property of animal bodies, by which one part or organ is induced to imitate, or compelled to follow the action of another part wherewith it has no direct connexion. Thus, for example, irritation of the bronchial tubes and diseases of the skin are very frequently succeeded by irritation of the mucous membrane of the bladder; irritation of the kidney is productive of nausea and vomiting; and similar effects are caused by vertigo and by oppression of the brain, in none of which instances is the organ primarily affected contiguous to that which sympathizes with it. In like manner, pain under the shoulder-blade is ordinarily symptomatic of diseases of the liver; indigestion occasions difficulty of breathing and headach; and uterine irritation or gestation excites the secretion of milk.

The influence of the generative function over the development of the body displays another curious illustration of sympathy. Children before the age

of puberty, and animals which have been castrated at an early period of life, in appearance as well as in character, bear a stronger resemblance to the female than to the male. The conformation and expression of the ox have all the effeminacy of the the cow; and in the human race, the eunuch is devoid of the beard, and his voice wants the tone which characterizes manhood. We are told by Mr. Scrope, in his Art of Deer Stalking, that if a hart be castrated when a fawn, it will never have horns, and if it be castrated when five or six years old, by which time the horns have attained their full growth, it will never drop them; or if it be castrated when it has dropped them, they will never be renewed.

I am also informed by my friend Mr. S. Cox, that if *one* testis be removed during the development of the testes in the month of May, *one* antler will alone be formed.*

In man, imperfect evolution of the genital organs is attended by a peculiar class of disorders, such as hysteria and chlorosis, in which both the nutritive and the animative functions are implicated.

The inclination to sympathize with one another is manifested by the intellectual as well as by the physical faculties; for what is the association of ideas but a species of sympathy?

* An account of several interesting experiments on deer is given in Russell's Economy of Nature in Acute and Chronical Diseases of the Glands.

In his anxiety to exhaust the subject, Müller has, however, enumerated among the sympathies several phenomena which appear to me to be nothing more than examples of extension of disease from one part to another. Of this description are the tendency of emphysema to spread through the cellular tissue; the participation of the glands in disorders of the lymphatic vessels; together with many similar instances, which like the foregoing are *continuous*, not *sympathetic* affections.

Sympathy is indispensably necessary to the preservation of that harmony between the various organs which is so essential to their healthy action, and therefore constitutes a most important office of the nervous system, to which it is justly ascribed, though physiologists have by no means agreed upon what set of nerves it depends. By some it is attributed to the sympathetic nerve; and by others to the agency of the brain and cerebral nerves; both of which opinions are, for the most part, well founded; but their respective advocates are certainly mistaken in claiming it as the exclusive function of any one division of the nervous system. From the phenomena of sensation and animal motion, and the connexion between them, we must, I think, feel convinced that sympathetic affections may arise from impressions either on the ganglionic, the spinal, or the cerebral nerves, and may be communicated through the medium of any of these divisions of the nervous system. All the *painful* as well as the *pleasing* sympathetic feelings are doubtless

the result of impressions upon some part of the cerebral system; and the association of ideas is clearly dependent upon the brain itself; but the organic sympathies, such as the secretion of milk in consequence of excitement of the uterus, and the increased vigour which the nutritive and animative functions acquire at the age of puberty from the stimulus of the genital organs and sexual propensities, are obviously effected by the spinal and ganglionic systems.

II. Besides the tendency of one organ to participate in the actions and sensations of another, there is also a species of sympathy existing between different individuals; such as that which causes the man who witnesses pain in a fellow-creature to become affected in a somewhat similar manner himself. This, however, is entirely the effect of imagination; for, as Adam Smith remarks, we place ourselves in the situation of the sufferer, "we conceive ourselves enduring all the same torments, we enter, as it were, into his body, and become in some measure the same person with him, and thence form some idea of his sensations, and even feel something which, though weaker in degree, is not altogether unlike them. His agonies, when they are thus brought home to ourselves, when we have thus adopted and made them our own, begin at last to affect us, and we then tremble and shudder at the thought of what he feels." "When we see a stroke aimed, and just ready to fall upon the leg

or arm of another person, we naturally shrink and draw back our own leg, or our own arm; and when it does fall, we feel it in some measure, and are hurt by it as well as the sufferer."*

Reasoning upon these well-known facts, and applying to them the laws of attraction, Cabanis was induced to conceive that animal sympathy is merely the result of a principle which pervades nature, and which is an inherent property of matter. He supposed that, in accordance with a general law, to which there is no exception, the particles of matter have an inclination to unite with each other; and that, as the combinations thus formed lose their elementary simplicity, they gradually acquire new tendencies, and manifest a certain affinity. To this principle he attributed the origin and development of animal bodies; all the phenomena by which life is manifested; the mysterious operations which cause the various organs to spring into existence; together with all those actions which indicate the appetites and inclinations. It is by this means, he says, that the parts of animals increase; that their waste is repaired; that their organization is perfected; and that their choice of food is directed.

In proportion as matter becomes animalized, the affinity between its particles increases; whence it arises that in inflammations we perceive the formation of new membranes into which the vessels and nerves of the affected organs extend themselves. In the same manner are formed cicatrices, the

* Moral Sentiments, vol. i. pp. 3, 4.

tissue of which presents all the phenomena of vitality, possessing heat, tone, and sensibility; and thus also the parts of organized bodies from which the cuticle has been removed unite like the grafts of trees, and have a common life.

Cabanis, therefore, believed that sympathy, or, as he defines it, the tendency of one living body towards other living bodies of the same or of different kinds, is the consequence of animal attraction. Being, however, modified by circumstances, it is liable to take various directions, and to assume different characters, according to the degree of sensibility with which the individual may be endued. It originates in the supposition that the being who may be the object of it entertains a reciprocal feeling; and we no sooner imagine a person to possess certain affections or antipathies as regards ourselves, than we are attracted toward him, or estranged from him. These propensities are, however, controlled by the judgment, and influenced by the senses.

It is unnecessary to remark that this theory is merely a visionary speculation, totally devoid of proof.

III. The instances of sympathy which have hitherto been adduced are either purely moral or purely physical; but there are others which have a mixed character, and depend upon the relation of the mind to the body. Since indeed the brain is the seat of the intellect and passions, as well as the

centre of a large portion of the nervous system, whence branches issue to almost every part of the frame; it might naturally be expected that the faculties of which it is the organ should sympathize with the functions of which its nerves are the agents: nor are facts wanting to prove the existence of this sympathy. The first allusion to this curious connexion between the body and the mind is found in the works of Hippocrates; who, when speaking of the difference of the climate in Europe and in Asia, remarks that the Asiatics are less warlike and more effeminate than the Europeans, because they are not subject to the same changes of temperature; neither are their minds or bodies aroused by sudden alarms, so that they become weak and cowardly. He also says that there are great differences among the several tribes which inhabit Asia: some being much superior to others as regards the understanding; a circumstance which he attributes to the varieties of the seasons and the weather.*

The importance of this subject likewise attracted the attention of our great countryman Lord Bacon, who especially points it out as a distinct branch of human philosophy. "For," he remarks, "I do take the consideration in general, and at large, of

* See the treatise Περὶ ἀερων, υδατων, τοπων. Hippocrates probably refers to the climate of Asia Minor, for his observations are by no means applicable to the whole of Asia. They show, however, that he had paid some attention to the subject of which we are speaking.

human nature to be fit to be emancipated and made a knowledge by itself: not so much in regard of those delightful and elegant discourses which have been made of the dignity of man, of his miseries, of his state and life, and the like adjuncts of his common and undivided nature; but chiefly in regard of the knowledge concerning the sympathies and concordances between the mind and body, which being mixed, cannot be properly assigned to the sciences of either. . . . . For the consideration is double: either how, and how far the humours and affects of the body do alter or work upon the mind; or again, how and how far the passions or apprehensions of the mind do alter or work upon the body."*

But, notwithstanding the impulse which this, together with most other departments of science, derived from the powerful mind of Bacon, the sympathy between the mind and body, though noticed by several metaphysicians, did not receive the consideration which it deserved until the end of the last century, when Cabanis published his Rapports du Physique et du Moral de l'Homme. In this great work, he first speaks of the influence of the corporeal affections on the mind, and secondly of the influence of the mental emotions on the functions of the body; to illustrate which, he gives a history of the sensations, and adduces numerous facts in support of his doctrines.

* The Advancement of Learning.

After the account which I have given of sensibility and the animal motions, and the frequent reference which has been made to the connexion between them, as well as to the control which the different senses exercise over each other, it can scarcely be necessary to state that the cerebral system is the medium of this species of sympathy; that irritation of any of its nerves must more or less affect the functions of the brain; and that impressions on the sensorium may be conveyed by the nervous filaments either to the external or to the internal organs, without any exercise of the will. Presuming then that the nature of this link is clearly understood, it only remains for me to trace the principal phenomena, by which the relation between the mind and body is displayed; and I shall in the first place speak of the influence of the physical functions upon the passions and intellectual faculties.

As the human frame progressively acquires strength from the time of birth, till an earlier or later period of life, and has no sooner arrived at perfection than it begins to decay, so during youth does the mind gradually attain powers which begin to decline almost as soon as they are perfected, and which, if existence be protracted unto its extreme limits, are ultimately lost.

During childhood, both the body and the mind are in their most active state, there is more sensibility, and the brain is larger in comparison with the other organs, than in more advanced life. Absorp-

tion, sanguification, and nutrition are exceedingly rapid; the muscular fibre increases in tonicity; the nervous system is highly irritable; and in proportion to the development of the organs which necessarily succeeds, the perception becomes acute, the mind inquisitive, and there is a greater or less aptness in imitating the acts of others. But when the physical powers are so far perfected that the limbs are able to sustain the weight of the body, and by the growth of the teeth the child, being rendered capable of masticating and digesting animal and vegetable food, abandons the milk of its mother for a more invigorating diet, the nervous matter and the muscles assume a firmer consistence, their functions take a wider range, and are exercised with more precision; locomotion is added to the faculties of the body, which were at first confined to the operations of nutrition, and the mind, no longer exclusively occupied in perceiving objects of the external world, turns towards itself, and by exerting the memory, recalls those ideas which the senses may have previously supplied.

I have elsewhere said that the faculties of the mind and those of the body are alike strengthened by exercise. The arm of the artisan is not indeed more surely invigorated by his daily toil than the intellectual capacity is enlarged by education; and thus the changes which are wrought in the various organs are aided by practice in perfecting the mental as well as the physical functions, in fitting the

latter to endure labour, and in cultivating perception, memory, imagination, and reason.

From birth until the twelfth or fourteenth year, the growth of man is usually regular and uninterrupted, except at the two periods of dentition, when there is often some degree of constitutional disturbance, which is extremely liable to impede the progress of nutrition; but at the age of puberty, a most remarkable alteration is suddenly effected. The development of a new function creates fresh desires, and seems to give a stimulus to all the organs. In man, the beard then first makes its appearance, and the voice assumes a deeper tone; in woman the breasts increase in size, and the figure acquires rotundity; while in both, the passions become more ardent, the imagination more vivid, and the expression of countenance indicates these changes of disposition. Between this epoch and that at which the body is perfectly matured is the season when the invention is most fertile, as we not only find by our personal observation, but also from the history of our poets, most of whose greatest works were either devised or executed in their younger days: whereas, when the physical functions lose their extreme activity, the ardour and imagination of youth are exchanged for a sounder judgment and more correct reasoning powers. The capacity both of the mind and of the body is then at its zenith; they can then undergo more fatigue, and are qualified for greater undertakings than at any other part of life. This continues as long as the

organs remain healthy, the muscles retain their tone, the nerves preserve their irritability, and the secretions possess their stimulating properties; but no sooner do the physical powers begin to fail than the mind becomes enfeebled.* First, the memory is impaired, then the attention flags, and afterwards the other mental faculties give way, until at length sensibility to all moral impressions is extinguished, the individual no longer recognizes external objects, and becomes like the new-born infant, an instinctive being. Thus, at every period, we find that the mental faculties correspond with the development of the body, and more especially of the brain.

The disposition and intellectual character are, however, at all ages modified by the constitution of the individual. It requires indeed little observation to perceive a relation between the external form and the movements of the body, the activity of its internal functions, and the energy of the mind. This seems to have been noticed in very remote times; for Hippocrates was a firm believer in the doctrine of the temperaments, which maintained that certain qualities of body and mind are connected with the predominancy of blood, yellow bile, black bile, or phlegm in the system; and so universally has this notion been adopted, that even at the present day we apply the appellation *sanguine* to

* This period varies very much in different individuals. Some persons retain the activity both of the mind and of the body even beyond the age at which human life ordinarily terminates.

persons of an excitable disposition, and *melancholy* to those who are desponding and low spirited: the former term having originally signified fullness of blood, the latter, black bile.

Although this division of temperaments is somewhat fanciful, and the causes which were supposed to produce these distinctions are quite inadmissible, yet it is impossible to deny that the external formation of the body must in some degree afford an index of the nervous power; and that any variety in the state of the secretions, by which they may be rendered more or less stimulant, would necessarily increase or diminish the energy of the cerebral system; besides which, the consistency of the brain itself, like that of the other animal solids, is affected by every derangement and modification of nutrition.

In persons of the sanguine temperament, the hair is soft and of a pale or chestnut colour, the eyes are blue or hazel, the circulation is rapid, the complexion florid, and the skin soft; the chest is broad, there is usually a tendency to fatness, the muscular parts are rather flaccid, and the mind irritable, quick, cheerful, and volatile. In such individuals, the broad chest allows space for a large air-apparatus, so that a great portion of blood is constantly flowing through the lungs, where, together with a lighter colour, it also acquires stimulant properties, which, by exciting the nervous system, increase the activity

* The best accounts of the temperaments are those of Hippocrates, Cullen, and Cabanis.

both of the nutritive function, and of the intellectual faculties.

In those of the melancholic temperament, on the contrary, the hair is harsh and black, the skin thick and coarse, the complexion pale or tinged with yellow, the eyes dark gray or black, the muscles are rigid, the circulation is slow, and the chest is usually narrow; the body seldom contains much fat, and the mind has little excitability. The perception is usually slow and the disposition grave, but impressions which have been once received are not easily lost; there is great perseverance with steady application to every undertaking, and capacity for the most profound reflection. In short, the mental and physical functions are as different as possible from those which indicate a sanguine habit, and exhibit a low state of excitability, combined with considerable muscular rigidity and strength.

The other two temperaments are merely modifications or compounds of those which I have mentioned; for if the circulation of a highly sanguine man were reduced in speed and power, he would probably become phlegmatic; and if the circulation of a melancholic man could be accelerated and invigorated, he would assume the bilious temperament.

It very commonly happens, indeed, that the temperament of an individual undergoes a thorough change during the progress of life, and that the constitution, which in youth was sanguine, is phlegmatic or melancholic at a more advanced age; for

while the circumstances which predispose to the former occur during the growth of the body, those which give a tendency to the latter prevail during its decline.

The temperament is also in some measure determined by the organic distinctions of the sexes. Since the generative secretions and the accumulation of blood in the sexual organs, by stimulating the nervous system, increase the energy of all the functions, give an impulse to nutrition, and excite the passions, the tone of the moral and physical faculties must vary in proportion to the intensity of the irritation which is thus operating upon the frame. This is shown by eunuchs, and by those who have passed the age of puberty, without having undergone the natural changes of constitution; in most of whom both the mind and the body are comparatively feeble and languid. It is, however, unnecessary to resort to an extreme case; for the contrast between the dispositions of men and those of women furnish a most striking illustration. Men have the higher degree both of mental and of physical vigour; they are usually more profound thinkers, more logical reasoners, and they possess more courage than the other sex. Women, on the other hand, are remarkable for acuteness of perception, for vivacity, and for sensibility; they are less robust than men, and of a more gentle disposition. Some of these distinctions between the male and female character are no doubt partly attributable to the very different modes in which boys and girls

are educated in all civilized countries; and there are many individual exceptions: but the principal characteristics of the mind, like those of the body, are found among savage tribes; and even in the brute creation, there is a vast difference between the sexes both in in temper and docility, as well as in figure. In every state of society, the mental peculiarities of the sexes correspond with their organization; in all nations man has the more powerful frame, the larger brain, the more condensed muscular and nervous fibres, and the more meditative mind; woman has a lighter and more elegant form, a more vivid imagination, and a quicker apprehension. Men are more inclined to the melancholic, women to the sanguine temperament.

The various constitutions of the body which are induced by age, temperament, and sex, are incessantly acting upon the mind. They are inseparable from our existence, and necessarily occur during the progress of life. But there are some extraneous circumstances which have an equal control over the mental functions; and among these none is more powerful than the influence of disease. Besides the organic affections of the brain which may destroy either perception or reason, the cerebral system is sympathetically affected by disorders of the nutritive and generative organs.

The melancholy disposition of the hypochondriac is increased by the slightest derangement of the stomach or liver, and is relieved by the restoration of the digestive secretions to a healthy state. In-

digestion has indeed a tendency to render irritable even the most tranquil minds, and to induce torpor in those which are most energetic; while the more severe disturbance of the alimentary canal, which is caused by the presence of worms, often occasions vertigo and convulsions, with suspension of the mental faculties.

In slighter disorders of the digestion, even when the mind is not sensibly affected in the day, during sleep at night the patient is apt to be haunted by nightmare and by dreams. In like manner, irritation of the genital organs may be productive of hysteria in women, of satyriasis in men, or of madness in either sex. The influence of corporeal diseases upon the mind is, however, so obvious, that it is unnecessary to mention other illustrations: for surely every one must have had opportunities of noticing the difference between the mental capacity of an individual when in the enjoyment of health and while suffering from bodily infirmity; the decline of memory, for example, in consequence of an attack of fever, and its gradual restoration as the organs regain their wonted vigour; whereas in the scrofulous and mesenteric affections, to which children are liable, the brain appears to be supernaturally stimulated, so that the intellectual development is hastened, and prematurely perfected.

But these phenomena are not more remarkable than the power which food and medicine exert in modifying the ideas and feelings. Since, indeed, lesions of nutrition so powerfully affect the mental

faculties, it unavoidably follows that those substances which nourish the body must have some influence upon them; but the peculiar mode in which each kind of aliment may act depends upon the constitution of the individual. Thus, a stimulant diet increases the intellectual activity of one person, and depresses that of another; the head of one man is clearest when he is fasting or living upon vegetable food; whereas others are incapable of applying themselves either to study or to business, until they have had an ample meal: while the intoxicating liquors, such as wine and brandy, which incapacitate one person, arouse the faculties and call forth the genius of others. Many of these apparent incongruities are, however, attributable to *habit*, which possesses a wondrous control over all circumstances relating to the animal economy.

By stimulating, allaying, or altering the action of the internal organs, medicines, like food, modify the intellectual functions of the brain; and that too whether we employ those substances which more especially operate upon the digestion, or those which act upon absorption, circulation, or secretion; for as all parts of the body are supplied with nerves, and as a current of blood is constantly flowing through the brain, the nervous matter is exposed to the influence of whatever medicinal agents may enter any tissue or may affect any function.

Hence the benefit which is derived from the use of cathartics and sedatives in disorders of the

brain. But the most marked instances of the influence of medicines on the mind are afforded by those which operate on the cerebral system itself, and particularly the narcotic poisons. All substances of this class have the property of destroying sensibility and inducing sleep, for which purposes they are very commonly prescribed in maladies attended with pain or irritability. In large doses they produce giddiness, stupor, and sleep. Sensation and the intellectual powers are entirely suspended, and death ensues. These, however, are not the only effects of narcotics on the mind, for the habitual use of them in quantities too small immediately to prove fatal, gradually annihilates the power of the nervous system, so as ultimately to cause paralysis and to impair the mental faculties.

A very curious circumstance with regard to the action of narcotics is the quality which some of them display of exciting the imagination. We are told by those who have been accustomed to take opium, that when under its influence, they experience the most delightful dreams and visions; accompanied with the most perfect state of tranquillity and ease. Of this, there is an admirable description in the Confessions of an English Opium Eater, to which I beg to refer the inquisitive reader.

The tendency to sleep which narcotics create has also its effect upon the understanding; for as bodily exercise, by contributing to health, increases the vigour of the brain, so does the excessive

indulgence of repose enervate and enfeeble its functions; the senses moreover become torpid for want of exertion, and the mind decays, because it has ceased to gain fresh ideas from external objects, and can only reflect upon those which the internal sensations or memory may supply.

It is needless to dilate upon the beneficial influence of physical exercise on the mind, since few can be ignorant of the exhilarating effect of a walk or ride after long application to business; for even if the attention be not overstrained, gloomy and uncomfortable ideas are apt to arise from any sedentary occupation, and nothing so soon restores the elasticity of the mind as active exertion of the body, especially when assisted by the stimulus of fresh air.

Among the circumstances which by their physical action influence the mind, I have, lastly, to mention climate. Its effects may be estimated by the vast difference between the tropical and the arctic animals; their respective colours, size, and habits; and although man is able to endure the vicissitudes of the seasons with less inconvenience than either quadrupeds, birds, fish, reptiles, or insects, yet the constantly repeated impressions of cold, or heat, of damp or of dry air, in time accomplish their work, and by modifying the consistency and the movements of the organs, alter his moral disposition.

Thus, we find that heat, which is so essential to the development of the body, by stimulating both the nutritive and animative functions, induces

puberty at a much earlier age in the inhabitants of the warm climates than in those of the colder regions; excites in them a higher degree of sensibility, with greater impetuosity of temper; and imparts more fervour to the imagination. Their passions are likewise exceedingly strong; but as over excitement is invariably succeeded by proportionate lassitude, they are usually indolent and fond of repose.

Cold, on the contrary, of which the primary action is less stimulant than heat, and the secondary effect more permanently sedative, causes comparatively little excitement of the body; creates less sensibility of the nervous system, and leaves the native of the north less susceptible of the more social and enthusiastic feelings. These, however, are only the effects of extreme degrees of temperature; for moderate heat is absolutely necessary to our well being; and moderate cold conduces to strength and activity; whence it happens that the nations of the temperate zones are of a more happy disposition, and for the most part surpass the rest of the world in intelligence, as much as they certainly excel them in personal beauty and in physical activity.

A curious example of the effects of climate on the human race is mentioned by Captain Marryat in his Diary in America.

"It is impossible," he says, "to imagine a greater difference in character than exists between the hot-blooded Southerner and the cold, calculating Yankee

of the eastern states. I have already said that there is a continual stream of emigration from the eastern states to the southward and westward, the farmers of the eastern states leaving their comparatively barren lands to settle down upon the more grateful soils of the interior. Now, it is a singular yet well-known fact that, in a very few years, the character of the eastern farmer is completely changed. He arrives there a hard-working, careful, and sober man; for the first two or three years his ground is well tilled, and his crops are abundant; but by degrees he becomes a different character: he neglects his farm, so that from rich soil he obtains no better crops than he formerly did upon his poor land in Massachusetts; he becomes indolent, reckless, and often intemperate. Before he has settled five years in the western country, the climate has changed him into a western man, with all the peculiar virtues and vices of the country."

The influence of dryness and moisture of the atmosphere on both the body and mind scarcely requires notice, for who does not experience a difference in the feelings on a fine and on a wet day? The one excites, and the other debilitates the nervous system; the one predisposes to the sanguine and bilious, the other to the phlegmatic and melancholic temperaments; the reason of which will be understood from what has been already said.

Thus, in all conditions of age, constitution, sex, and climate, do the mental faculties sympathize with the physical functions.

Of the influence of the mind upon the body, a very few words will suffice, since I have more than once alluded to this subject in speaking of sensation and the animal motions; when I stated that independently of volition, the passions powerfully affect the corporeal functions. In some instances they modify the natural sensations, and in others actually create disease. Thus, hunger is excited by the anticipation of food, while fear and sorrow destroy the appetite: mental anxiety promotes thirst; and the venereal desires are almost as much aroused by imaginary as by real objects. Some of the passions increase the secretion of saliva; others cause an intense inclination to void urine; and most of them either accelerate or depress the respiration and circulation. Hence, the frequent occurrence of disease of the heart from long-continued mental uneasiness, which, by increasing its action, ultimately causes both enlargement of its cavities and thickening of its walls. At the period of the first French Revolution, Corvisart met with an unusual number of these cases, which he very justly attributed to the agitation that then prevailed at Paris. Nor have the passions much less influence on the digestion than on the circulation. I am acquainted with a lady, in whom a sudden alarm brought on an attack of jaundice in the space of a few hours; and it not unfrequently happens that if a man who is in perfect health, and has just made a hearty meal, unexpectedly receive intelligence of some calamity, such as the death of a friend, or the loss of pro-

perty, his digestive organs sympathize with the brain, and symptoms of dyspepsia ensue.

The influence of the passions upon the ultimate process of nutrition, is sufficiently proved by the emaciation which distress of mind very commonly occasions; and by the alteration which has been observed to take place in the colour of the hair, from excessive sorrow and anxiety. A single night of mental agony has been known to change the hair from dark to gray.

The emotions of the mind also exercise a remarkable power over the functions of the uterus; in some cases suspending, and in others exciting the menstrual discharge; sometimes retarding parturition, and often causing abortion.

The beneficial effect of cheerful society upon the health of invalids, together with many other examples of the influence of the mind upon the physical functions, might be here adduced; but a further accumulation of illustrations is needless, since enough has been said to establish the fact.

The sympathy between the mind and the body is of the utmost importance to our welfare. It not only preserves harmony between the functions, and prevents the one from wearing out the other, but it likewise so connects them, that being mutually affected by the changes which may be wrought by education, disease, age, climate, or any other circumstances, they simultaneously acquire new temperaments suited to the region wherein the individual may live, and to the habits which he may

have found it necessary to adopt. If the European when resident in India, were to retain his natural energy and activity of mind, the physical powers would inevitably sink under the debilitating influence of a tropical sun; while the indolence of the Asiatic would be quite as little adapted to preserve him from cold and hunger in the more northern countries.

Whenever, indeed, the balance between the moral and physical functions is destroyed, the results are most disastrous: for what can be more pitiable than the condition of the maniac, who, unconscious of bodily suffering, will endure fatigue and famine until his emaciated frame can no longer sustain the burden of life? or what is more contemptible than the man whose passions survive his strength, and whose appetites remain when the power of gratifying them has ceased?

CHAPTER XVI.

OF INSTINCT.

INSTINCT is the propensity and ability to perform, independently of volition, certain actions which in the higher animals, except at the earliest period of life, are usually controlled by the will, and which are essential to self-preservation. It is the substitute for reason in the lower tribes which are destitute of the cerebral system, and in the higher animals, before the brain is sufficiently perfected for the exercise of the intellectual faculties.

Thus, in man, SUCKING, which at a more advanced age is a voluntary act, immediately after birth is purely instinctive, being merely a species of absorption, excited partly by internal impressions, partly by irritation of the lips on their coming in contact with the nipple, the finger, or some other substance. All the movements of the fœtus in utero, and of the young bird in the egg, are likewise instinctive and altogether unconnected with volition. CRYING is another instance of a similar description, and, as I have already said, may be produced by any impulse which brings the muscles of the glottis into such a position as to disturb the

current of air in its passage to and from the lungs. In like manner, the natural evacuations require not the interference of volition for their performance; and during typhus fever, or any disorder by which the sensorial faculties are suspended, they take place involuntarily: but these, as well as all the other instinctive actions, are constantly subject to mental control in those animals which possess a cerebral system, except when its functions are impaired either by injury or by disease. When, however, the power of the brain is destroyed, the instinctive faculties take up a portion of its task, as in the instances which I mentioned when speaking of positive sensation, wherein animals from which the cerebrum had been removed walked, flew, cried, and sucked.

From these facts it is obvious that the instinctive actions are independent of the brain; but there can be no doubt that they are the result of nervous influence, since the nerves are the sole excitors of the animal motions; so that we can only refer them to the spinal and ganglionic systems. This inference is also confirmed by anatomical researches; for it is found that, in proportion to the prevalence of instinct over intellect, so are the spinal and the ganglionic systems large in comparison with the cerebral system. Thus, man, who is the most intellectual of animated beings, has the largest brain in proportion to the other nervous centres; while many of the lowest tribes, which are *alone* entirely destitute of intellect, and whose movements are purely instinctive, are merely provided with one or more nervous cords representing

the spinal system, or with a few nervous masses constituting the ganglionic system; and nothing resembling a brain with its appendages is visible: whereas in others, no nerves whatever have yet been discovered, though, as I have elsewhere remarked, it is probable that they contain some portion of neurine, either in the form of very minute granules, or diffused through the substance of their bodies. Nor do these simple animals require the aid of intellectual powers; for being nourished by imbibing or rather absorbing the water which they inhabit, or the particles of vegetable matter which float in it, they have no occasion to seek for food, and are therefore neither in want of locomotive organs nor of a mind to guide them; while the perpetuation of the species is effected by the excretion of eggs, or spawn, which being impregnated without coition, there is no need of sensual inducement to the act. They are not susceptible of positive sensations, and have none of the external organs of sensation, with the exception of a thin cuticle.*

Proceeding higher in the animal kingdom, we find that at every step the instinctive actions become more and more modified by the intellectual powers, until at length in civilized man, the former merge in the latter. But through all these grades, the nature and causes of the instinctive faculties

* The mode in which some of the polypi are affected by light as little proves intelligence as the inclination of flowers to turn toward the sun. It only shows that their bodies are sensible of the stimulus of heat

remain unchanged; they in every instance consist of involuntary movements of the external organs, produced by the impressions on the nerves of negative sensation, in the same manner as the contractions of the heart or of the diaphragm during sleep.

A negative sensation is created either by an external, or, more commonly, by an internal stimulus; and an impulse being given to the nervous matter, the external organ is set in motion; all which series of operations together constitute the phenomena of instinct. In the radiata, this faculty seems to be exercised by ganglia and their nerves; while in the young of the vertebrated animals the spinal system is probably its instrument. There is, therefore, no analogy between the instinctive and the voluntary motions; the former being the result of the organic impulses arising from the excitement of either the spinal cord or the ganglia by the external and internal stimuli; the latter being regulated by the intellectual functions of the brain.

Instinct has, nevertheless, been treated by most persons who have written on the subject as an inferior species of intellect, as a principle inherent in the brute creation and as a substitute for reason, of which the existence is erroneously denied in any but the human race. Believing, however, that every animal, in which the cerebral system is perfectly developed, must possess some kind of understanding, though its capacity doubtless differs in the various tribes, according to the organization of the brain, as its inclinations do according to the num-

ber and acuteness of the senses, I think that I can see a wide line of demarcation between the instinctive faculties as I have described them, and those actions of the quadruped and the bird which seem to me to manifest volition, but which are almost universally attributed to instinct. To dissipate this confusion of terms and ideas, let us examine some of the circumstances which are most commonly adduced as examples of instinct, at the same time keeping in mind its real phenomena.

Among the instances of instinct none is more frequently mentioned than the ingenuity with which birds construct their nests. It has indeed been observed that those which have been taken from the parent and confined in a cage soon after they have been hatched, and which can have had therefore no communication with others of their own species, build with as much skill as those which are at liberty; whence it has been very plausibly argued that they cannot have obtained their skill either from imitation, sensation, or reason. This is surely a strange doctrine; for if there be anything in nature, the subtle mechanism of which proves it to have been the work of an intelligent being, the curious structure of a bird's nest, the selection of situation and materials, together with its admirable adaptation to the purpose for which it is intended, certainly display a degree of contrivance which can only be an attribute of intellect.

There are, however, some birds which do not seem to take much trouble in constructing a habita-

tion for their young; but even these tribes carefully deposit the egg in a suitable place, the very choice of which demonstrates their consciousness of its value; and I should as easily be induced to believe that the inhabitants of Leeds and Manchester have the instinctive faculty of weaving cloth, as that a bird could make its nest without the exercise of mind, or would make it without some object in view.

The construction of the nest in many species constitutes one link in a chain of actions, all of which seem to show that the bird is aware of the necessity of such preparations. First, it pairs with one of the other sex; then, by their united efforts, they build a nest in which the female lays her eggs and sits upon them until the young are hatched; and lastly, they feed and protect their offspring as long as their care is required. All this manifests a degree of foresight which will bear comparison with that exhibited by the human race under similar circumstances. The same passions induce the union of the sexes; the same sensations doubtless warn them of approaching parturition; the same affections instigate anxiety for the welfare of their progeny; and the pleasurable feelings which the female of one class of animated beings experiences from suckling its young, that of the other probably derives from sitting on its eggs: while the intellect of each suggests the most appropriate means of accomplishing the purposes of its existence.

It would be vain to speculate on the mental

qualities which are peculiar to each tribe of animals; but since we know that many of them, as the parrot and the dog, in common with ourselves, possess memory, the power of imitation, and other faculties, I am led to the conviction that their various capacities, though in every instance far inferior to our own, are nevertheless regulated by the same laws which govern the human understanding; and that their dispositions and propensities, like ours, chiefly depend on the nature and acuteness of their senses. Hence, with few exceptions, the greater ferocity of the carnivorous than of the herbivorous animals; the ardour of the dog in pursuing game, to which he is apparently attracted by his acute smell; and the predominancy of the sexual passions in almost all the higher orders of the brute creation at certain seasons, when being stimulated by the heat of the atmosphere or other circumstances, the genital organs are more than usually excited.

The senses of the lower animals are also, like our own, subject to illusion. On the flower* of a species of stapelia, which has the odour of putrid flesh, the carrion fly lays its eggs, apparently supposing that the plant is actually decayed animal matter, and that it thus provides a suitable bed for its young. The mistake of one scent for another might have been made by any human being, had the plant been put under the nose, when the eyes were

* See Bostock's Physiology.

shut; for he could only have corrected the error of the smell by comparing its impressions with those of feeling or of sight. But the carrion fly whose smell is probably far more acute than any of its other senses, is misled by the predominant sensation; an accident which could scarcely have happened had its actions been solely guided by instinctive feelings, which are regulated by impulses that can never be misled by the sensible qualities of external objects.

The congenital propensities of the aquatic birds to enter the water, of the partridge to pick up grain, and of the kitten or puppy to seek the breast of its mother, are in like manner the effect of pleasing sensations which they experience from the sight, smell, or feeling of the substances by which they are attracted; while the development of their organs being far more perfect at the time of birth than in the human race, they are able to accomplish acts which the child, even if it had the desire, would not have the power to perform.

The care with which animals nurse their young is dictated by the same affections which animate our own species; they display the same love for them during life, and sorrow for their premature death. Can all this spring from instinct alone? If the care of their young were instinctive, how could they feel sorrow, which is one of the passions that cannot exist without a motive, and is therefore necessarily connected with intellect; or why should sorrow remain when the offspring are dead, and no

longer possess any attractive qualities except such as the memory retains?

It is remarkable that the lower we go in the scale of intellect, the less dependent is the progeny upon the parent; and in the radiata which have no brain, the young are able to provide for themselves from the moment of birth.

Should it however be denied that brutes are capable of affection, look at the elephant, the horse, and the dog—the sincerity of whose attachment to his master might shame most human friendships.

The watchfulness of the female over the animal which she has brought into the world is not attributable to any instinctive relation between them: for a hen which has hatched a brood of ducks exhibits quite as much anxiety for them as if they were chickens: so that we can only ascribe it to the recollection of agreeable sensations which she supposes to have been connected with their existence, to sympathy with their helpless condition, or to some other association of ideas, with which we are unacquainted.

Nor is the fear which the weaker animals entertain towards those that are stronger than themselves, or of which they are the natural prey, to be regarded as instinctive. It is, as in man, the effect of an intellectual process, being the result either of experience, of imitation of the parent, or of other animals belonging to the same species; or, if the object be witnessed for the first time, of the surprise with which the brute creation, like savages of the human

race, behold anything which they are not accustomed to see. An excellent illustration of this occurred at the gardens of the London Zoological Society, when a tortoise was presented to the orang-outan, which is thus described in the Penny Magazine: "As the tortoise crawled along, the orang-outan stood aghast in an attitude of amazement ludicrously theatrical; nothing could induce it to pass the crawling object of its distrust. It would appear, however, that familiarity with the sight of the tortoises easily removed the apprehensions of the orang, for after this had seen a tortoise a few times, it exhibited less annoyance at the creature's presence. Whatever instinctive fear the orang or chimpanzee may entertain towards the larger snakes, or indeed snakes of any size, some of which are to be dreaded for their poison, it cannot, we think, be imputed to such an instinct that the orang is amazed or alarmed at the presence of a tortoise, inasmuch as the tortoise is utterly incapable of inflicting the slightest injury; we must therefore attribute the amazement of the young orang rather to the strange appearance of the animal,—an animal so unlike every living thing which it had hitherto witnessed, an animal of suspicious aspect, and the qualities of which it had yet to prove, than to any innate fear implanted as a preservative."

These remarks afford the true explanation of what is called *instinctive fear;* and many examples of a similar kind to the foregoing might be cited. Thus, if a rabbit be put into the cage of a boa-

constrictor, at first, it is very much alarmed, but after a few hours it will walk over the reptile, without displaying any symptom of fear. So likewise in the human race, we find that children usually shun a stranger, the expression of whose countenance is harsh or disagreeable; yet I never heard of any child who showed an antipathy to its mother or the nurse, by whom it had been kindly treated, however ugly she may have happened to be. Another instance of the caution and sagacity of animals was displayed by the elephant at the Zoological Gardens. A pond was made for him to bathe in; but nothing could induce him to enter it till the water had been drawn off, and he had ascertained that the bottom was firm.

Animals are, also as susceptible of anger as they are of fear and affection; nor indeed is there any creature, with whose modes of expression we are acquainted, that does not occasionally manifest this passion. The indication of it in the dog, the cat, and the horse are as obvious as in man, and bear as strong evidence of its connexion with the intellectual faculties. In every instance it arises from mental irritation; for while the anger of a strange dog or cat is readily excited by the infliction of pain, one with which we are familiar will utter a cry; but will not retaliate as long as it can endure the suffering. It has received kindness from us; it does not conceive that we wish to hurt it; and its habitual attachment prevents all vindictive feelings; whereas, if anger were instinctive, it would invari-

ably follow all similar applications of the stimulus by which it had been once produced; so that if we were accidentally to injure a domestic animal, we should be as likely to suffer from its fury as though it had been a perfect stranger.

The influence which the sense of smelling exerts over the sexual appetites of the higher animals is another proof that their passions are not merely instinctive; for as the sight of a beautiful person is a source of excitement in the human race, so does the scent of the female call forth these desires in many of the brutes.

In short, the passions of those animals which possess the cerebral system are, as in man, inseparably connected with intellect; while the instinctive faculties are always independent of the brain, and dependent either upon the spinal or upon the ganglionic system.*

There is, however, a vast difference between the relative power of the intellectual and instinctive faculties in man, and in those brutes which even most nearly approximate to him in the organization of the nervous system. It is the prerogative of the human mind to acquire by education and culture of the moral principles such an ascendancy over the appetites as to make them subservient to the higher purposes of our existence; whereas, teach them as you may, the elephant, the dog, and the horse still remain emphatically *sensual* beings.

* The section on Instinct in Darwin's Zoonomia is highly worthy of perusal.

CHAPTER XVII.

OF SLEEP, DREAMING, SOMNAMBULISM, AND REVERIE.

I. HALLER says that sleep arises either from a deficiency or immobility of the spirits, or from compression of the nerves; in both of which cases the passage of the spirits through the cerebrum is impeded:* and he supposed that this state may be induced either by excessive acceleration or languor of the circulation of the brain; by any circumstances which may cause external or internal pressure; or by exhaustion from labour.† Much the same doctrine was held by Boerhaave who, after stating that sleep is the effect either of obstruction to the secretion, or of alteration in the circulation of the nervous spirits, adds that it is an affection of the cerebrum, but not of the cerebellum.‡ Cullen believed that sleep and waking depend upon the greater or less motion of the nervous fluid, but not upon any difference in its quantity; that during sleep the movements in the brain are diminished, and a degree of collapse takes place; while for the

* Primæ Lineæ Physiologiæ, p. 310.

† Elementa Physiologiæ. Lib. xvii. sect. iii. p. 11.

‡ Prælectiones Academicæ. De Somno, p. 593.

exercise of the voluntary functions, it is necessary that the organ should be in a state of excitement.* Bichat conceived sleep to be the consequence of a general law of animal life, that the functions require periodical rest:† and Blumenbach attributes it to a diminished or impeded flow of oxygenated or arterial blood to the brain.

None of these theories appear to me to explain the phenomena of sleep. Those which attempt to account for it by the supposition that the blood affords a greater pressure and stimulus to the brain at one part of the day than at another,‡ are founded upon pathological observations which are not applicable to sleep; for the coma which is induced by congestion of the cerebral vessels has none of the refreshing influence of natural repose. In sleep the brain is never totally inert, being constantly subject to the action of the internal stimuli, feeble, though it be in comparison with that of external objects; but in coma, the cerebral power is entirely suspended, and the brain is insensible to all the stimulants, so that it is more nearly allied to death than to sleep; and even if the analogy were admitted, it would only substitute one difficulty for another.

Neither by this theory, nor by those hypotheses which assume the existence of a subtile fluid in the

* Physiology, pp. 127, et seq.

† Recherches Physiques sur la Vie et la Mort. Art. iv. p. 2, 3.

‡ Elliotson's Physiol. Fifth ed. p. 610.

brain, is any plausible reason afforded for the periodical intermission of the cerebral action, and this is the point which I shall now endeavour to explain.

The distinction which Bichat has drawn between the functions of organic and those of animal life is perfectly just; the former are in constant operation from birth until death, the latter periodically rest; but he is satisfied with laying down the fact, as a law, without analyzing the causes upon which it depends. From the view which I have given of sensation, intellect, mobility, and instinct, it would seem that during sleep the action of the cerebral system apparently ceases, while that of the spinal and ganglionic systems continues: the positive sensations and voluntary motions are extinct, but the negative sensations and the involuntary motions remain.

The impressions which create the positive sensations being for the most part of a more stimulant nature than those from which the negative sensations arise, excite in the brain a degree of activity to which the spinal cord and ganglia are rarely subject; and as it is a law of the animal economy, that the *exhaustion of an organ is proportional to the intensity of its exertion*, so in the one instance there is a marked respite from labour; while in the other there is scarcely any perceptible remission.

Nevertheless, the periodical variations of pulse, the greater tendency to sickness and debility in the morning than in the evening, together with many

other circumstances, show that the spinal and ganglionic systems are susceptible of fatigue, and have their diurnal relaxations and exacerbations. In the cerebral system, the existence of this law is manifested by the tendency to sleep, which is induced by violent mental or bodily exercise, as well as by the passions; though depression of the cerebral powers may be also occasioned by opium, and other narcotics, which possess the peculiar property of diminishing nervous irritability.

In like manner, cold and other sedatives, and the attention to a single sensation, such as that arising from the murmur of a brook, or the repetition of numbers, which though itself of too little importance to excite very intense interest, yet is sufficient to attract the mind from more weighty matters, are also conducive to sleep.

Another cause of sleep is the partial cessation of stimulating impressions on the organs of positive sensation; for as the nervous matter never acts except under the influence of a stimulus, the brain becomes torpid as soon as it is freed from the objects which are habitually conveyed to it by the nerves. Hence, the exclusion of light and sound tranquillizes the cerebral system and promotes repose; and the same effect would ensue with regard to the spinal and ganglionic systems, if it were possible temporarily to suspend the negative sensations; but the stimuli which cause them being essential to the motion of the vital organs,

are constantly in action during life, and are only withheld at the moment of death.

The respiration and the circulation are however retarded during sleep, but this is probably owing to the loss of the sympathetic excitement which all parts of the body experience from the mental emotions, while the mind is in action. So important, indeed, is the presiding influence of the brain over the animal economy, that if this great reservoir of nervous power be so much injured, either by apoplexy, or any other disease, or by mechanical force, that it is no longer able to perform its functions, nutrition invariably becomes disordered, and sometimes life is extinguished.

II. Although during sleep the external senses are no longer affected by surrounding objects, the internal positive sensations, arising from the stimulus of the viscera, the secretions, and the food continue in force. While, however, the nutritive and generative functions are in their ordinary state, the impressions which they communicate to the cerebral nerves are not sufficiently vivid to awaken the intellectual faculties; but whenever the internal organs become disordered, they produce more intense sensations, which, by exciting the cerebrum, occasion that state of the memory and imagination which constitutes DREAMING. Under these circumstances the mind, either directed by the present sensations or reverting to past impressions, forms

new combinations of ideas, and frequently raises up to itself images which have no real existence.

That dreams originate from the impulse given to the brain by the internal stimuli is evident from the influence which indigestion, difficulty of breathing, irritability of the genital organs, and other maladies, exercise over the imagination when external objects are excluded from the senses, as they usually are in sleep. During disturbed or imperfect repose, however, we are sometimes partially conscious of events which are taking place around us, and our dreams are in some measure guided by them. A curious instance of this happened to a person of my acquaintance, who while asleep in bed dreamed that a man was entering his room through the window, and had broken the water jug in attempting to step over it. The gentleman started up, and seizing a pistol which lay under his pillow, was about to shoot at the intruder, when most fortunately awaking, he discovered that the supposed thief was his own servant, who having come to call him in the morning, had accidentally broken the jug; the noise of which had doubtless been heard by him, and given colour to his dream.

It has been justly observed by Dugald Stewart, that the same laws of association which regulate the train of our thoughts while we are awake continue to operate during sleep;* nevertheless, the extravagance and incongruity of most dreams show that

* Philosophy of the Human Mind, chap. v.

though the memory and imagination are active, the judgment is almost passive in their formation:

> "Dreams are but interludes that Fancy makes;
> When monarch Reason sleeps, this mimic wakes."

This probably results from the exclusion of the more acute sensations, for it is well known that in the dark and in solitude, the imagination is very apt to overpower reason. The exhausted state of the brain during sleep may perhaps, moreover, incapacitate it for exercising the most arduous of its functions.

III. Of the phenomena connected with dreaming, none is more remarkable than SOMNAMBULISM, or sleep-walking, and yet it is a very natural consequence; for although external sensation is suspended, the mental faculties are still in operation; and should the train of thought happen to be such as to create a motive for physical exertion, the organs which are under the influence of volition are just as likely to be called into action as if the individual were awake. The mental process is the same in both cases. Sensation promotes reflection, whence springs the wish to move; and the will calls into action the motory nerve which stimulates the muscular fibre. This explanation is opposed to the doctrines of Stewart and Darwin, both of whom held the opinion that the influence of the will is always suspended during sleep, and so it is when the repose is perfect and undisturbed; but the

analogy between the working of the mind in dreaming and somnambulism and the exercise of our faculties while we are awake affords an argument in favour of the view which I have taken, that seems to me unanswerable. Let the mind be deprived of its judgment, as it is in lunacy, and the products of its other faculties very much resemble our dreams, and the actions of the individual are not unlike those of the somnambulist.

IV. As allied to sleep, I must also mention REVERIE, which consists in the exclusive attention either to a single sensation or to a single set of ideas; the mind being entirely abstracted from all others. It is an intermediate state between sleep and waking; which, as Hartley says, differs from imagination only inasmuch as the person, being more attentive to his own thoughts and less disturbed by foreign objects, receives more ideas from association and fewer from new impressions.

Reverie does not, however, necessarily either occasion or succeed sleep; nor is it the effect of the same causes; for it frequently occurs without any exhaustion of the nervous power, and even happens while the external senses are subjected to the irritation both of light and of sound.

CHAPTER XVIII.

OF DEATH.

In the foregoing pages, I have endeavoured to explain the relation of sensation to the other functions of animal bodies, and to show that since the objects of sense possess the property of stimulating the nervous matter, the faculty of receiving and transmitting impressions is not only essential to the excitement of the involuntary motions and to the cultivation of the intellectual powers, but that, by its influence upon the mind, it likewise exercises a control over the *will,* and thus *indirectly* assists in calling into action the voluntary organs.

Sensation therefore, being equally indispensable to the discharge of the mental and physical functions, is necessarily coexistent with life, and only ceases with it.

The causes of death may indeed be classified according to the mode in which they impair the nervous power.

1st. Disorganization of the nervous system and destruction of its influence.

To this division belong severe mechanical injuries

and morbid changes, either of the nervous centres or of nerves attached to vital organs, such as concussion of the brain, wounds of the medulla oblongata, and softening of the nervous matter.

2dly. Pressure either upon the nerves or upon their centres; as by the depression of the skull, and by congestion of the blood-vessels.

3dly. Abstraction of the nervous stimulants, such as loss of blood, and diminution of its stimulant properties either from want of food or exclusion of air; or from organic affections of the heart, lungs, and secretory organs.

4thly. Application of excessive or abnormal stimulants, and substitution of them for the natural stimulants. Under this head may be classed the action of most of the animal, vegetable, and mineral poisons; most of the diseases to which the human race is subject including inflammation and fever; violent shocks of electricity and of other powerful agents.

When from any cause the functions either of the ganglionic or of the spinal system cease, some portion of the vital organs is immediately paralysed; but when death ensues either from mental affections, or from disorder of the cerebral system, it is probably to be attributed to the sympathetic in-

fluence which powerful impressions on the brain invariably produce upon the respiratory organs.

As the power of the cerebral system over the other organs is greater in the highest class of animals, in them are its disorders most frequently fatal; and accordingly we find that while the chicken, for example, has been known to live for months after the cerebrum had been removed, a violent emotion of the mind, even without any organic lesion, is capable of terminating the life of man.

APPENDIX TO CHAPTER I.

In speaking of the older physiologists, with the name of Hoffmann I ought to have mentioned Willis and Baglivi, both of whom seem to have had considerable insight into the powers of the nervous system.

The *De Animâ Brutorum* of Willis is a most able work, and especially worthy of attention.

The *Archæus* of Van Helmont very nearly resembles the *Anima* of Stahl; and both may perhaps be regarded as personifications of the nervous influence.

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